DOCUMENT RESUME

ED 174 454 SE 028 519

AUTHOR Cole, Charles A.; And Others
TITLE A Bachelor of Engineering Technology Curriculum in Water Quality Management: Course Guides.
INSTITUTION Pennsylvania State Univ., University Park.
SPONS AGENCY Environmental Protection Agency, Washington, D.C. Div. of Manpower Training.
PUB DATE [78]
NOTE 129p.; For related document, see SE 028 518

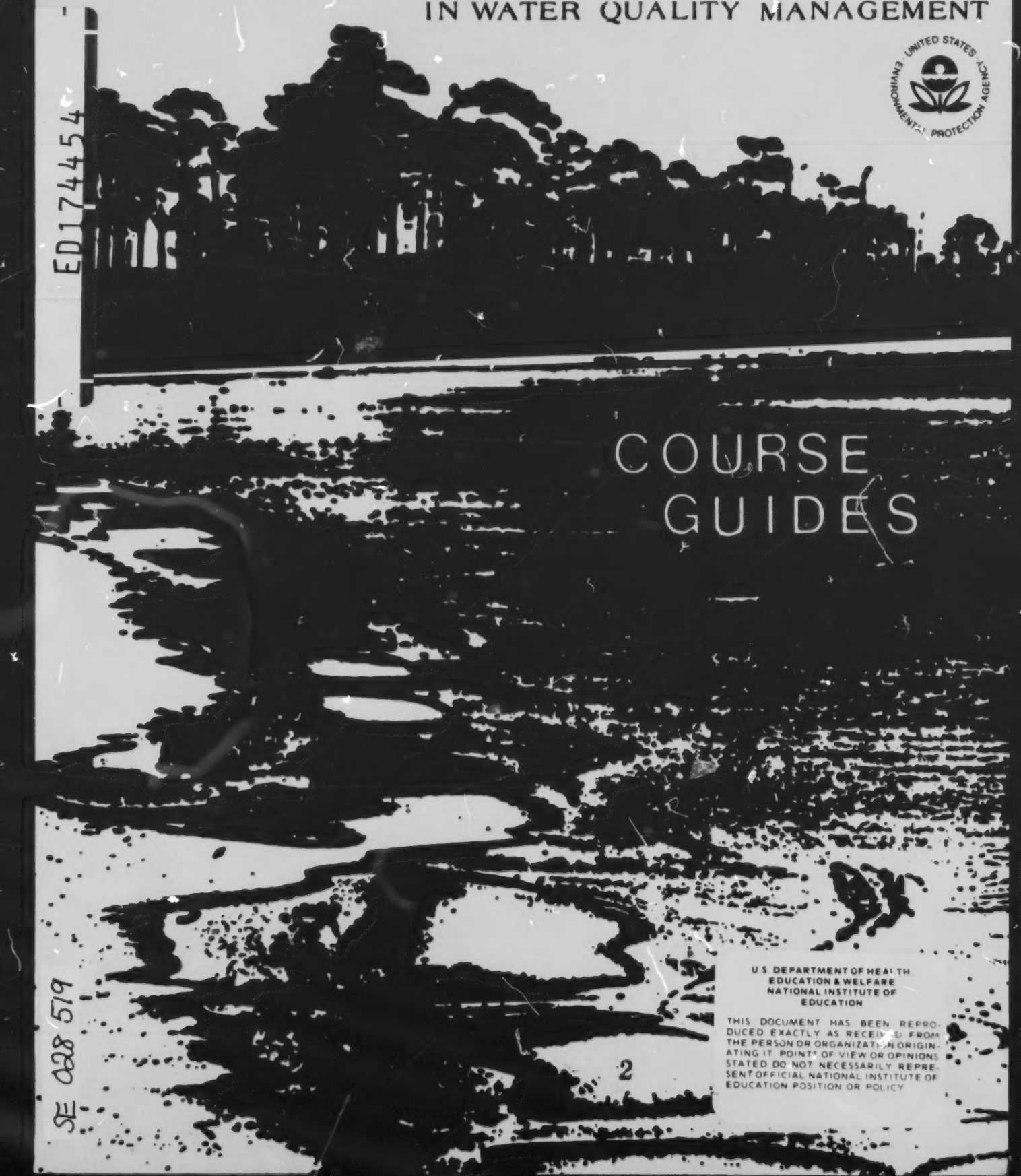
EDRS PRICE MF01/PC05 Plus Postage.
DESCRIPTORS Certification; *Curriculum; *Degree Requirements; Engineering; Job Skills; Management; *Postsecondary Education; *Professional Education; Science Education; *Technical Education; Undergraduate Study; *Water Pollution Control
IDENTIFIERS *Water Quality Management

ABSTRACT

Contained are course guides for a Bachelor of Engineering Technology (BET) Curriculum in Water Quality Management. Detailed course content, as well as instructional resources, are included in this volume. Each guide is written in behavioral terms using the instructional objective format. A suggested curriculum is shown with methods of implementation for two-year, four-year, or continuing education programs. Courses listed include: biology, microbiology, engineering surveys, fluid mechanics, hydrology, treatment plant operations, and water pollution abatement. (CS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

A BACHELOR OF ENGINEERING TECHNOLOGY CURRICULUM IN WATER QUALITY MANAGEMENT



COURSE GUIDES

ED174454

SE 028 519

U.S. DEPARTMENT OF HEALTH EDUCATION & WELFARE NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

A Bachelor of Engineering Technology Curriculum in Water Quality Management

Course Guides

PROJECT FUNDED BY

Training Grants Branch
Division of Manpower Training
US Environmental Protection Agency

BY

Charles A. Cole, Project Director
The Pennsylvania State University

William A. Welsh
The Pennsylvania State University

Lorna Chr. Stoltzfus
The Pennsylvania State University

For Information

ON FUNDING OF INSTRUCTIONAL PROGRAMS

Manpower Planning and Training Branch
Municipal Operations and Training Division
Office of Water Programs Operations
US Environmental Protection Agency
Washington, DC 20460
202/426-7887

ON PROJECT ADMINISTRATION AND CURRICULA DEVELOPMENT

Charles A. Cole, Project Director
Water Resources Engineering Technology Program
The Pennsylvania State University
Capitol Campus, W-261
Middletown, PA 17057
717/783-6133

ON PROGRAM IMPLEMENTATION

William A. Welsh, Program Chairman
Civil Engineering Technology Program
The Pennsylvania State University
Capitol Campus, W-261
Middletown, PA 17057
717/783-6125

ON COURSE DESCRIPTIONS

Lorna Chr. Stoltzfus, Asst. Prof. of Chemistry
Civil Engineering Technology Program
The Pennsylvania State University
Capitol Campus, W-261
Middletown, PA 17057
717/783-6124

Acknowledgements

This project was funded by the Training Grants Branch, Division of Manpower and Training, US Environmental Protection Agency. The work was carried out at The Pennsylvania State University under project No. T900704010. The material developed under the Grant was reviewed by an advisory committee listed on the following page. Their input into the curriculum development was invaluable.

In addition we would like to thank Gujar N.S. Rao, Assistant Professor of Engineering at The Pennsylvania State University, for his assistance in preparing course objectives. The instructional objective format for the courses is based on advice and previous work of John H. Austin, former Professor and Head of Environmental Systems Engineering, Clemson University. The IRIS searches used for the instructional resources were done by James Kozlow, ERIC Clearinghouse for Science, Mathematics and Environmental Education, The Ohio State University. We also thank Mrs. Ann Kirsch and Patti Souders for typing the many drafts of this document.

Water Quality Management Advisory Committee

John H. Austin, Vice-President
The MAXIMA Corporation
962 Wayne Avenue
Silver Springs, MD 20910

Lou Bercheni, Assistant Director
Bureau of Water Quality Management
Pennsylvania Department of Environmental Resources
P. O. Box 2063
Harrisburg, PA 17120

Raymond Best, Vice President
Buchart Horn Consulting Engineers & Planners
612 West Market Street
York, PA 17405
(Supervisor Silver Spring Township)

John Coscia, Director
Environmental Planning Division
Delaware Valley Regional Planning Comm.
1819 J. F. Kennedy Blvd.
Philadelphia, PA 19103

Walter Groszyk, Department Director
Water Planning Division
US Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

David Long, Associate Professor of Engineering
Environmental Engineering Department
The Pennsylvania State University
218 Sackett Building
University Park, PA 16802
(ECPD Engineering Technology Accreditation Team)

Thomas Rachford, Deputy Chief
Project Management & Planning Section
Gannett Fleming Corddry & Carpenter, Inc.
P. O. Box 1963
Harrisburg, PA 17105

Carroll Sauer, Manager
208 Projects Section
Baltimore Regional Planning Council
701 Saint Paul Street
Baltimore, MD 21202

Jekabs Vittands, Vice President & Project Manager
Metcalf & Eddy Inc.
50 Staniford Street
Boston, MA 02114

Table of Contents

Page

FOR INFORMATION ii
ACKNOWLEDGEMENTS iii
INTRODUCTION vi
SUGGESTED FOUR-YEAR WATER QUALITY MANAGEMENT TECHNOLOGY CURRICULUM vii
HOW TO USE THE COURSE GUIDES viii
A GLOSSARY OF VERBS x
LOCATING THE INSTRUCTIONAL RESOURCES xiii
DETAILED COURSE GUIDES
- Biology 3
- Chemistry I 11
- Chemistry II 19
- Water/Waste Water Chemistry and Microbiology (Lecture) 27
- Water/Waste Water Chemistry and Microbiology (Laboratory) 33
- Engineering Surveys 41
- Environmental Sanitation 49
- Fluid Mechanics 59
- Water Quality Management 69
- Water Quality Management Internship 77
- Water Pollution Abatement 83
- Hydrology and Water Supply 91
- Operation and Control of Treatment Plants 99

Introduction

This publication contains course guides for a Bachelor of Engineering Technology Curriculum in Water Quality Management. Detailed course content, as well as instructional resources, for the following technical specialty courses in water quality management are included in this volume: Biology, Chemistry I and II, Water/Wastewater Chemistry and Microbiology, Engineering Surveys, Environmental Sanitation, Fluid Mechanics, Water Quality Management, Water Quality Management Internship, Water Pollution Abatement, Hydrology and Water Supply, Operation and Control of Treatment Plants. Each guide is written in behavioral terms using the instructional objective format explained in the following section on how to use the course guides. Summaries of the support courses for the curriculum can be found in a companion publication entitled *Curriculum in Water Quality Management: Program Implementation.*

This curriculum can easily be used by other institutions to enhance their educational programs. As designed, the curriculum may be offered as a 2 + 2 program by a two-year community college working in conjection with a four-year or an upper division institution. Implementation of the entire curriculum as a four-year program is a second alternative. A suggested curriculum is shown in the table on the following page. A third alternative is the utilization of individual course guides in continuing education workshops and training programs for various water and wastewater professionls.

The completion of the course guides for this water quality management curriculum provides a foundation for future expansion of the guides into separate student and instructor editions with more detailed methods of evaluation of student performance and sections describing student and instructor activities. Further flexibility could be built into the curriculum if it were modularized to include self-paced learning units for individual course topics. In addition any curriculum development done in a dynamic area, such as water quality management, should be periodically reviewed by an advisory group and then revised to keep course content current with the state-of-the-art.

SUGGESTED FOUR-YEAR WQM TECHNOLOGY CURRICULUM

Year	Semester	Course	Title	Credits
I	I	English I	Fundamental Composition and Rhetoric	3
I	I	Math I	College Algebra/Trigonometry	4
I	I	Chemistry I	Chemistry I	4
I	I	Humanities	Humanities Elective	4
				15
I	II	English II	Technical Writing	3
I	II	Math II	Technical Math with Calculus	3
I	II	Chemistry II	Chemistry II	4
I	II	Biology	Biology	3
I	II	Social Science	Social Science Elective	4
				17
II	I	Physics I	Fundamental Physics	4
II	I	Drafting I	Fundamental Drafting	2
II	I	Math III	Applied Calculus	4
II	I	Mechanics I	Statics	4
				14
II	II	Physics II	Technical Physics	4
II	II	Math IV	Applied Calculus & Differential Equations	4
II	II	Mechanics II	Strength of Materials	4
II	II	Chemistry III	Water/Wastewater Chemistry and Microbiology	5
				17
III	I	Electricity I	Applied Electricity	2
III	I	Environmental Control	Environmental Sanitation	3
III	I	Civil Engineering I	Elementary Structural Design	4
III	I	Mechanics III	Dynamics	4
III	I	Surveys I	Plane Surveying	2
III	I	Civil Engineering III	Engineering Economy	2
				17
III	II	Water Quality Management	WQM Planning	3
III	II	Mechanics IV	Fluid Mechanics	4
III	II	Math V	Computer Programming	4
III	II	Civil Engineering II	Engineering Construction Materials	3
III	II	Surveys II	Engineering Surveys	2
				16
SUMMER			WQM Internship	3
IV	I	Civil Engineering IV	Water Pollution Abatement	4
IV	I	Math VI	Statistics	3
IV	I	English II	Informative Speaking	2
IV	I	Humanities	Humanities Elective	4
IV	I	Elective	Technical Elective*	4
				17
IV	II	Civil Engineering V	Hydrology and Water Supply	4
IV	II	Civil Engineering VI	Operation and Control of Treatment Plants	4
IV	II	Social Science	Social Science Elective**	4
IV	II	Elective	Technical Elective*	4
				16
			Total	132

*Suggest public administration or planning course.
**Suggest course related to impact of technology on man and the environment.

How to Use the Course Guides*

Each of the course guides is designed to help the instructor direct the learning activities of students. The emphasis throughout is on competent performance of required tasks by students. All activities suggested in the guides are designed to equip the student with the ability to perform, not just to fill his/her head with knowledge.

The format of the guides may be unfamiliar to some users. An explanation of the format and how to use the guides follows; it is suggested that the user look at a typical page in a course guide while reading.

PURPOSE

This section explains the importance of the course to the learner. It puts the course objectives in perspective with other things the learner may be studying and shows how achieving the objectives will help the learner after s/he completes training and begins working. Information of this kind is often highly motivating to a learner; the instructor should always take time to explain the "why" of a lesson.

PREREQUISITES

Often some particular knowledge or skill which is taught in another lesson in the curriculum is needed before a learner can understand and profit from a particular lesson. The prerequisites section specifies the courses which the learner must complete before studying the new material.

This curriculum is structured in such a way that each course builds upon the ones that precede it. If this sequence is altered or departed from, care must be taken to ensure that the learner accomplishes prerequisite material before attempting a course dependent on it.

COURSE OUTLINE

Each topic of instruction represents a complete subject area of a course. A list of the topics and the corresponding instructional objectives which make up a particular course are given at the beginning of each course.

INSTRUCTIONAL RESOURCES

This two-part section lists learning aids which can be used to achieve the instructional objective. The majority of the resources recommended are printed materials, although films, slides, and other audio-visual aids may also be recommended. An instructor may substitute comparable resources for those given in the course guides.

Suggested Textbooks/Reference Materials. This section lists books which cover all the topics discussed in the course, as well as reference books that are useful for the particular subject area. The numbers listed are reference codes for IRIS (Water Quality Instructional Resources Information System). The IRIS index must be consulted to identify the resources for each lesson. An explanation of how to locate the instructional resources is given on page xiii.

Other Instructional Resources. This part suggests additional learning aids which an instructor may use for reference for specific topics covered in the course.

INSTRUCTIONAL OBJECTIVES

These three-part objectives make up the important part of the course. An instructional objective states what the learner is to do (action/terminal behavior); describes the situation in which the learner performs for evaluation (conditions); and establishes a proficiency level for the learner's performance (acceptable performance).

*Adapted from Wastewater Engineering Technology Programs: Course Guides for Instructors. Implemented by E. R. Baker, Clemson University, and W. A. Wockenfuss, University of Maryland. March 1978.

The authors wish to emphasize that the instructional objective describes a goal which the learner should achieve. It describes not what the student will do while learning, but rather what the student will do when performing for evaluation.

Action/Terminal Behavior (ACT). This part always requires that the learner perform actions which are observable or audible (e.g., draw, describe, list, demonstrate) rather than actions which cannot be seen or heard (e.g., appreciate, become familiar with, know). A glossary of verbs used in the action/terminal behavior statements is included on page x.

Conditions (COND). This part lists the tools, equipment, reference materials, and job aids to which the learner will have access while performing for evaluation.

The user should note that the conditions recommended are those which closely conform to the on-the-job conditions which the learner will encounter after training. In the event that realistic conditions are not accessible during training, suggestions are made for closely simulating working situations (e.g., scale models, case studies, photographs, role-playing).

The authors of these guides hold the view that the learner should not arbitrarily be required to perform from memory unless absolutely necessary. There is a tendency in training programs to require trainees to memorize lengthy formulas and processes, while actual on-the-job situations the trainee would be free to consult an available reference for a formula or process. Frequently the conditions given in the course guide prescribe that the learner be given a performance aid (e.g., a set of instructions) to which s/he may refer while being evaluated. In most cases, this performance aid can be taken from one of the instructional resources; failing that, it should be written by the instructor.

Acceptable Performance (PL). This part describes the minimum level of competency or proficiency which the learner should demonstrate when performing the action/terminal behavior for evaluation. It also details the points which should be included in a learner's definition or description for it to be judged satisfactory. However it is recognized that all learners do not attain perfection at every performance. It is necessary though that s/he obtain some minimum knowledge in order to be considered to have mastered the overall topics.

USING COURSE GUIDES TO PREPARE INSTRUCTIONAL SESSIONS

The instructor should prepare for instructional sessions by first consulting the course guide to decide how many instructional objectives can be covered in each class session. Next, the instructor should gather all materials specified to be used by the learner, such as tools, equipment, performance aids, and the selected IRIS resources (or substitutes) to be studied by the learner.

The instructor should then write or prepare the test(s) to be used for evaluating the learner's achievement. Finally, the instructor should guide the student through the session and evaluate his/her performance.

Correct and full use of these course guides will lead to teaching that is systematic and in line with the latest developments in instructional technology. The result will be competence and achievement in graduates.

A Glossary of Verbs

This glossary is included here to explain the sometimes specialized uses of verbs in these materials. The list includes verbs used in describing action/terminal behavior and acceptable performance. These definitions will enable both the instructor and the student to know exactly what actions the student must perform in order to achieve a performance objective.

VERB	*DEFINITION*	*EXAMPLE OF USE*
CALCULATE	To compute mathematically.	*Calculate* the numerical value of the unknown.
CLASSIFY	To arrange according to class or category.	*Classify* the molecules as linear, bent or trigonal.
COMPARE	To examine in order to note the similarities or differences of. Sometimes paired with CONTRAST.	*Compare* the absorption spectrum of the sun to the emission spectrum of hydrogen. *Compare and contrast* products of mitosis meiosis.
DEFINE	To state the precise meaning of (a word).	*Define* the term "hypothesis."
DEMONSTRATE	To manifest, show or display.	*Demonstrate* the procedure for collecting solids.
DESCRIBE	To tell about in detail; to represent by words written or spoken for the knowledge or understanding of others; to picture verbally.	*Describe* the process of photosynthesis. *Describe* safety procedures for the collection system.
DETERMINE	To ascertain, discover or establish.	*Determine* the chlorine demand of six types of wastewater.
DISCUSS	To talk (or write) about in detail.	*Discuss* possible sources of inaccurate results.
DRAW	To draft or sketch.	*Draw* a diagram of a treatment plant.
EVALUATE	To ascertain, judge or fix the value or worth of.	*Evaluate* the effectiveness of the coagulant as a sludge conditioner.
EXAMINE	To inspect or look at a thing in detail.	*Examine* the components of the instrument.

VERB	*DEFINITION*	*EXAMPLE OF USE*
EXPLAIN	To make plain or clear; to present in detail.	*Explain* why it is necessary to remove pollutants from wastewater.
GIVE (same as STATE)	To state, write or list.	*Give* the equation for the coefficient of viscosity.
IDENTIFY	1. To give the name of an object when shown the object itself or a representation of it.	1. *Identify* the process unit shown in the diagram.
	2. To establish as possessing a distinguishing characteristic or set of characteristics.	2. *Identify* from a list of all government agencies those agencies which are involved in environmental control.
LIST	To enumerate or itemize.	*List* uses of ultraviolet-visible spectrophotometry.
MEMORIZE	To commit to memory; learn by heart.	*Memorize* titles of the three major pieces of legislation on environmental control.
NAME	To supply from memory the name of.	*Name* three types of respiration.
OBSERVE	To look at attentively; to pay attention to.	*Observe* the demonstration.
PERFORM	To carry out an action or pattern of behavior. (Implies an act for which a process or pattern of movement has already been established, especially one calling for skill or precision or for the assignment of responsibility.)	*Perform* the normal operation procedures for a collection system.
POINT OUT	To indicate the position or direction of, especially by extending a finger toward the thing so indicated; to direct someone's attention to.	*Point out* distinguishing features of the check valve.

VERB	*DEFINITION*	*EXAMPLE OF USE*
PRACTICE	To exercise or perform (something) repeatedly in order to acquire skill, proficiency, and expertness.	*Practice* using the laboratory balances.
PREPARE	To make or get ready.	*Prepare* the equipment for use.
RANK	To classify, place in order.	*Rank* the elements in order of their electronegativity.
SELECT	To choose from among several, usually by fitness, excellence or other distinguishing feature.	*Select* the locations for sampling.
SPECIFY	To state explicitly.	*Specify* measures which will correct the abnormality.
STATE (same as GIVE)	To set forth in words; to declare.	*State* the main ideas of the Darwinian Theory of evolution.
STUDY	To examine closely.	*Study* the periodic chart.
VIEW	To look at attentively.	*View* the slides or photographs which illustrate the correct procedure.

Locating the Instructional Resources

The instructional resources listed in the introductory material for each course can be used to aid the student in learning the subject matter, to help the instructor in gathering lecture materials, and to furnish more in-depth information on a particular topic. The resources identified by the code IRIS are from a computerized information base containing the instructional resources listed in a publication called *A Compilation of Water and Wastewater Treatment Instructional Materials: Abstracts and Indexes*, which is available from:

ERIC Clearinghouse for Science, Mathematics and Environmental Education
The Ohio State University
1200 Chambers Road, 3rd Floor
Columbus, OH 43212

Phone: 614/422-6717

This publication will be released mid-1979 and will contain some of the original IRIS (Water Quality Instructional Resources Information System) entries, as well as new entries from ERIC (Educational Resources Information Center) tapes.* Resources of varied media types – slides, films, self-instructional packages, as well as printed materials – are listed in the publication.

In order to obtain the listed instructional resource material, the instructor should:

1. Obtain a numerical listing of the instructional resources from the address given above. This list is available both in printed form and on microfiche.

2. Using the numbers listed after the code letters IRIS found in the introductory pages of each course in this guide, locate the same number in the computer listing. Each number in the listing is prefaced with the code letters EW and is the identification number assigned sequentially to documents as they are processed into the information base. Each number refers to a given instructional resource. An example showing the format of the listing and the type of information accompanying each entry is shown on page xiv.

3. Obtain the resource from a library or order the resource from the originating source listed or from EDRS (ERIC Document Reproduction Services, P. O. Box 190, Arlington, VA 22210). To order a particular resource from EDRS the ED number must be used; this number is printed as part of the bibliographic information in the computer listing entry.

The resources identified by the codes MP, XT, and VC are films, slide-tape units and videocassettes, respectively, and are listed in an EPA publication entitled *Water Quality Control Instructional Materials*. This catalog of audio-visual aids is available from:

National Training and Operational Technology Center
Office of Water Program Operations
U. S. Environmental Protection Agency
Cincinnati, OH 45268

Phone: 513/684-7501

The audiovisuals aids can be obtained from the NTOTC lending library at the same address.

* The original IRIS tape was used for this work, therefore only listings up to EW 002905 were searched.

Sample Instructional Resource Entry

1 CLEARINGHOUSE ACCESSION NUMBER: EW003000

2 ACCESSION NUMBER: ED151161

3 PUBLICATION DATE: JUN 74

4 TITLE: WASTEWATER SAMPLING METHODOLOGIES AND FLOW MEASUREMENT TECHNIQUES.

5 PERSONAL AUTHOR: HARRIS, DANIEL J; KEFFER, WILLIAM J.

6 INSTITUTION CODE: BBB06039

7 DESCRIPTOR: ENVIRONMENT; *EQUIPMENT STANDARDS; *LABORATORY PROCEDURES; *POLLUTION; *POST SECONDARY EDUCATION; PUBLIC HEALTH; *SAMPLING; SANITATION; *WATER POLLUTION CONTROL; WATER RESOURCES; *WASTE WATER TREATMENT.

8 EDRS PRICE: EDRS PRICE MF-$0.83 PLUS POSTAGE. HC NOT AVAILABLE FROM EDRS.

9 DESCRIPTIVE NOTE: 156P.; NOT AVAILABLE IN HARD COPY DUE TO MARGINAL LEGIBILITY OF ORIGINAL DOCUMENT

10 ISSUE: RIEJUL78

11 ABSTRACT: THIS DOCUMENT PROVIDES A READY SOURCE OF INFORMATION ABOUT WATER/WASTEWATER SAMPLING ACTIVITIES USING VARIOUS COMMERCIAL SAMPLING AND FLOW MEASUREMENT DEVICES. THE REPORT CONSOLIDATES THE FINDINGS AND SUMMARIZES THE ACTIVITIES, EXPERIENCES, SAMPLING METHODS, AND FIELD MEASUREMENT TECHNIQUES CONDUCTED BY THE ENVIRONMENTAL PROTECTION AGENCY (EPA), REGION VII, FIELD INVESTIGATIONS SECTION. THE RESULTS OF FIVE SEPARATE SAMPLER PERFORMANCE STUDIES ARE REPORTED WHICH INDICATED SIGNIFICANT DIFFERENCES BETWEEN AUTOMATIC COMPOSITORS AND MANUAL SAMPLING METHODS.

12 (CS)

13 REPORT NUMBER: EPA-907/9-74-005

14 INSTITUTION NAME: ENVIRONMENTAL PROTECTION AGENCY, WASHINGTON, D.C.

Key to Sample Instructional Resource Entry

1. Number used in this course guide to reference a particular instructional resource; it is an identification number assigned sequentially to documents as they are processed.
2. Number to use when ordering resource from ERIC Document Reproduction Service (EDRS).
3. Publication date.
4. Title.
5. Author(s).
6. Institution code number; name and address of institution are listed at the end of the entry. A sponsoring agency may also be listed; this is the agency responsible for initiating, funding, and managing the project.
7. Subject terms which characterize substantive content. Only the major terms, preceded by an asterick, are printed in the subject index.
8. Availability of resource from EDRS. "MF" indicates microfiche; "HC" indicates hard copy, i.e., reproduced paper copy. When described as "Not Available from EDRS," alternate sources are cited above. Prices are subject to change; for latest price schedule see page on "How to Order ERIC Documents," in the most recent issue of *Resources in Education*, an ERIC publication.
9. Descriptive note includes pagination, notes on copy, etc.
10. Issue of *Resources in Education* where entry is listed.
11. Informative abstract.
12. Abstractor's initials.
13. Report number assigned by originator.
14. Institution and/or sponsoring agency's name and address.

Detailed Course Guides

Biology

PURPOSE

The purpose of this course is to assist the learner in acquiring basic fundamentals of modern biology. The origin, the cellular basis, and the basic biological, chemical and physical processes of life will be discussed. Sections on microorganisms and on the interrelationships of organisms, including ecological systems, will be included since they are of particular importance in the area of water quality management.

PREREQUISITES

The prerequisites for this course are meeting the requirements for acceptance into the BET Program. This course is a prerequisite for Environmental Sanitation and Water/Wastewater Chemistry and Microbiology.

COURSE OUTLINE

The topics covered in this course are listed below. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Basic Concepts in Biology	1,2
Characteristics of Living Things	3,4
The Cell	5-11
Animal Plant Tissue	12-14
Diffusion and Osmosis	15
Reproduction	16,17
Energy Sources	18,19
Respiration	20
Taxonomy of Living Things	21
Microorganisms	22-24
Genetics	25-28
Origin of Life	29-32
Ecological Systems	33-39

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the student in learning this subject matter, to help the instructor in gathering lecture materials, and to furnish more in-depth information on a particular topic.

IRIS 2053

Noland, G. B. and Weaver, W. C. *General Biology*. 9th ed. St. Louis, MO: C. V. Mosby Co., 1975.

Instructional Objectives

Upon completion of this course, the learner will be able to

1
ACT Define the following terms: science, biology, hypothesis, law, theory.

COND From memory.

PL Terms should be correctly defined.

2
ACT List the six steps involved in the scientific method and explain each step.

COND From memory.

PL List should include the following, in this order: (1) recognition of the problem, (2) observation, (3) formulation of a hypothesis, (4) experimentation, (5) evaluation of data, (6) drawing conclusions.

3
ACT Name and define the seven characteristics which all living things possess.

COND From memory.

PL The following characteristics should be named and defined: organization, metabolism, growth, irritability, motion, reproduction, adaptation.

4
ACT List the seven chemical components of which all living things are composed.

COND From memory.

PL List must include the following: water, minerals, carbohydrates, lipids, proteins, enzymes, nucleic acids.

5
ACT State the three major concepts in the theory of the cell.

COND From memory.

PL The following concepts should be stated; all living things are composed of cells; the cell is the basic unit of life; all cells come from preexisting cells.

6
ACT Define DNA (deoxyribonucleic acid) and RNA (ribonucleic acid); describe the shape and size of their molecules; and list their components.

COND From memory.

PL List should include sugars, 5 bases (adenine, guanine, cytosine, thymine, and uracil), and phosphates.

7
ACT Identify on a diagram the following ten components of cellular structure: cell wall, plasma membrane, endoplasmic reticulum, ribosomes, lysosomes, mitochondria, golgi apparatus, cytoplasmic vacuoles, plastids, nucleus.

COND Given an unlabelled drawing of the structure of a cell.

PL At least 8 of the 10 cellular components should be accurately identified.

8
ACT Match cell components and their functions.

COND Given a list of the ten components of the cellular structure and a list of their functions.

PL Functions of at least 8 of the cell components should be correctly identified.

9
ACT Describe the role of the cell in maintaining life.

COND From memory.

PL Description should include the cell's functions in food production, energy utilization, biosynthesis of basic life chemicals, water regulation, and storage of fats and other substances.

10
ACT Draw and label diagrams which illustrate two types of cell division – mitosis and meiosis. Each of the stages in these processes should be shown in the diagrams.

COND From memory.

PL Diagrams should show the four stages of mitosis and the eight stages of meiosis.

11
ACT Compare and contrast the products of mitosis and of meiosis.

COND From memory.

PL Comparison should point out that, whereas both types of cell division produce new cells, mitosis produces two daughter cells (diploid cells) and occurs in somatic tissue; while meiosis produces four daughter cells (haploid cells) and occurs only in sex cells.

12
ACT Describe the differences between plant and animal cells.

COND From memory.

PL Description should point out that plant cells are larger and have vacuoles, plastids, and cellulose walls; while animal cells are smaller and have a distinct center and thin walls.

13
ACT Identify the five primary types of animal tissue and give at least one example of each.

COND Given color slides or photographs of the following types of tissue: epithelial, connective, vascular, muscular, nervous.

PL Identification of at least four types of tissue should be correctly done.

14
ACT Name nine primary types of plant tissue.

COND From memory.

PL The following types should be named: meristematic; ground meristem; procambium (temporary tissues); parenchyma; sclerenchyma; collenchyma; cork (simple permanent tissue); phloem; xylem (complex permanent tissue).

15
ACT Define the following biological processes: diffusion, osmosis.

COND From memory.

PL Definition of diffusion should include random movement and effect of temperature. Definition of osmosis should include permeability, semipermeability, and differential permeability.

16
ACT Describe sexual reproduction in living organisms.

COND From memory.

PL Description should state that sexual reproduction requires two parents (male and female); involves an exchange of genetic material; and includes meiosis in sex cells only.

17
ACT Describe asexual reproduction in living organisms.

COND From memory.

PL Description should include that asexual reproduction requires one parent only; involves no exchange of genetic material; and includes binary fission, budding, and sporulation.

18
ACT Define the following terms which are organisms classified according to how they feed: heterotrophs, saprophytes, parasites, autotrophs, holophytes, chemotrophic autotrophs, mixtrophs.

COND From memory.

PL At least 5 of the 7 organisms should be correctly defined.

19
ACT Describe the process of photosynthesis, explaining it as a source of food supply for plants. The chemical equation for photosynthesis should be given.

COND From memory.

PL Description should explain the roles of sunlight, chlorophyll, carbon dioxide, oxygen, and water and should state that glucose is the end product of the process. The following equation should be written:

$$6\,CO_2 + 6\,H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6\,O_2$$

20
ACT Name three types of respiration and describe the process of respiration in living things.

COND From memory.

PL The following types of respiration should be named: cellular, aerobic, anaerobic. Description of respiration should include gas exchange, fermentation, glycolysis, and the importance of the pyruvic acid cycle.

21
ACT List the seven classes used to classify all living things, beginning with the smallest class and working upwards to the largest.

COND From memory.

PL The following classes should be listed in this sequence: (1) species, (2) genus, (3) family, (4) order, (5) class, (6) phylum, (7) kingdom.

22
ACT Describe what a virus is, give two examples of viruses, and describe how they endanger man's health.

COND From memory.

PL Description should define a virus as a submicroscopic pathogen consisting of a core of a single nucleic acid surrounded by a protein membrane.

23
ACT Describe blue-green algae (Cyanophyta), list two examples, and explain how these microorganisms affect water quality.

COND From memory.

PL Description should mention the procaryotic nature of blue-green algae, but that their photosynthetic mechanism resembles photosynthetic bacteria.

24
ACT Describe the characteristics of the following classes of protozoa and give one example of each: Sarcodina, Mastigophora, Sporozoa, Ciliaphora. Also explain how these organisms endanger man's health.

COND From memory.

PL Description should state that Sarcodina move by amoeboid motion; Mastigophora, by flagella; Ciliaphora, by cilia; and Sporozoa are usually non-motile and parasitic on higher animals.

25
ACT Define the following terms which describe fundamental concepts in genetics: homozygous, heterozygous, monohybrid, dihybrid, incomplete dominance, lethal genes, allele, linkage, chromosome, crossover.

COND From memory.

PL At least 8 of the 10 terms should be accurately defined.

26
ACT Name and explain Mendel's laws of genetics.

COND From memory.

PL Explanation should include the following: law of dominance, law of segregation, law of independent assortment.

27
ACT Solve a problem in genetic crossing in peas of a monohybrid cross (homozygous tall x homozygous dwarf) and determine the genotype and phenotype ratios expected.

COND Given a Punnett square and the following problem:

TT x tt = ?, where T = tall and t = dwarf

PL Determination should be to the F_2 generation. The correct symbols should be used throughout.

28
ACT Solve a problem involving an entire monohybrid cross in guinea pig inheritance (heterozygous rough x heterozygous rough) and determine the genotype and phenotype ratios expected.

COND Given a Punnett square and the following problem:

Rr x Rr = ?, where R = rough hair and
r = smooth hair

PL Determination should be worked to the F_1 generation. The correct symbols should be used throughout.

29
ACT List sources of evidence which give support for a theory of evolution.

COND From memory.

PL List should include at least four of the following sources: paleontology, taxonomy, comparative embryology, comparative physiology, heredity.

30
ACT State the main ideas of the following major theories on the origin of life: abiogenesis, biogenesis, autotroph hypothesis, heterotroph hypothesis, organic chemical evolution.

COND From memory.

PL Description of these theories should be 70% correct.

31
ACT Compare and contrast the Larmarckian and Darwinian theories of evolution.

COND From memory.

PL Comparison should include that the Larmarckian theory postulates gain or loss of inherited characteristics based on amount of use; while the Darwinian theory postulates natural selection and survival of the fittest.

32
ACT Discuss the main ideas of Devries' theory of evolution.

COND From memory.

PL Discussion should include the theory of mutation from sudden and unpredictable changes in genes.

33
ACT Define the following terms which describe fundamental concepts of ecological systems: individual, population, community, biome, ecosystem.

COND From memory.

PL Terms should be correctly defined.

34
ACT Define the term *ecological succession* and list at least three types of ecological succession.

COND From memory.

PL List should include at least 3 of the following types of ecological succession: primary, secondary, bare rock, autotroph, heterotroph.

35
ACT Define the terms *primary succession* and *secondary succession* and give two examples of each kind of succession.

COND From memory.

PL Definition of primary succession should include the development of vegetation in areas that were not previously inhabited by plants. Secondary successions are those that begin on soil after natural vegetation has been destroyed.

36
ACT Draw and label a diagram showing open-water succession in a pond. The diagram should include the following: changes in pond depth; accumulation of silt and organic material; planktonic organisms; saturated soil plants; larger emergents and emergent aquatics; rooted floating and rooted submerged leaves.

COND From memory.

PL All features listed above should be shown in the diagram.

37
ACT Define the following terms which describe ecological factors of a terrestial ecosystem and give two examples of each factor: abiotic factors, producers, microconsumers, macroconsumers, decomposers.

COND From memory.

PL At least 4 of the 5 terms should be accurately defined.

38

ACT Draw and label a diagram of a food chain in an aquatic ecosystem, beginning with producers and ending with consumers. The diagram should show sunlight; producers; first, second, and third order consumers; algae; copepods; small fish; large fish; man.

COND From memory.

PL Diagram should indicate the order of sequence of the biological components in the food chain.

39

ACT Draw and label a diagram of a food pyramid containing a minimum of five organisms. The diagram may represent any appropriate food chain sequence (e.g., the biotic pyramid).

COND Given a base of 1000 lbs. of green algae, four consumers, and a ten percent yield.

PL Diagram should be drawn and labelled correctly.

Chemistry I

PURPOSE

The purpose of this course is to assist the learner in gaining an understanding of the fundamental principles of chemistry and their applications. The learner will study the application of scientific methodology, physical and chemical properties of matter, principles of stoichiometry, atomic structure, periodic properties, chemical bonding, thermochemical reactions, and physical behavior of gases. Laboratory exercises in the course demonstrate the fundamental principles of chemistry and give the learner practice in using common laboratory equipment.

PREREQUISITES

Before beginning this course the learner should have mastered the instructional objectives for College Algebra and Trigonometry (Math I). This course is a prerequisite for Chemistry II.

COURSE OUTLINE

The topics covered in this course are listed below. The numbers of the instructional objectives which cover the various topics are also given.

Topic	Objective Number(s)
Definition of Scientific Method	1,2
Scientific Measurements	3-5
Physical Properties of Matter	6-8
Basic Particles	9,10
Stoichiometry	11,12
Atomic Structure	13-15
Periodic Chart	16,17
Chemical Bonding	18-20
Chemical Nomenclature	21
Thermochemistry	22-24
Physical Behavior of Gases	25-28
Laboratory Safety	29
Laboratory Experiments	30

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the student in learning this subject matter, to help the instructor in gathering lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

IRIS 1321, 1322

Brown, Theodore L., and LeMay, H. Eugene, Jr. *Chemistry: the central science.* Englewood Cliffs, NJ: Prentice-Hall, 1977.

Masterton, William L., and Slowinski, Emil J. *Chemical Principles.* 4th ed., Philadelphia: W. B. Saunders Co., 1977.

Other Instructional Resources

Definition of Scientific Method	IRIS 2052
Scientific Measurements	IRIS 945, 948, 2079, 2098, 2105, 2106, 2112, 2113, 2114, 2116, 2150, 2151, 2152, 2153, 2534, 2911
Physical Properties of Matter	IRIS 1791, 2115
Basic Particles	IRIS 1092
Stoichiometry	IRIS 1064, 2117, 2118, 2119
Atomic Structure	
Periodic Chart	IRIS 1092
Chemical Bonding	IRIS 1092
Chemical Nomenclature	IRIS 1092
Thermochemistry	
Physical Behavior of Gases	IRIS 406, 2119
Laboratory Safety	IRIS 942, 931, 1341, 1342, 1510, 1511
Laboratory Experiments	IRIS 926, 927, 929, 938, 939, 940, 944, 945, 946, 947, 948, 1060, 1355, 1358, 1359, 2097, 2098, 2151, 2152, 2153, 2157, 2911, 2302

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT Define the following terms: chemistry, science, fact, hypothesis, law, theory.

COND From memory.

PL At least 5 of the 6 terms should be correctly defined.

2
ACT List the six steps involved in the scientific method and explain each step.

COND From memory.

PL List should include the following, in this order: (1) recognition of the problem, (2) observation, (3) formulation of a hypothesis, (4) experimentation, (5) evaluation of data, (6) drawing conclusions.

3
ACT Demonstrate the use of the following laboratory measuring devices: metric ruler, thermometer (°C and °F), measuring and volumetric glassware, balance, barometer.

COND Given the necessary laboratory equipment and a laboratory procedure instruction sheet.

PL Demonstration should include the correct usage and handling of each piece of equipment.

4
ACT Using the English and SI systems of measurement convert lengths, masses, volumes, and temperatures from one unit to the other.

COND Given conversion factors for SI units.

PL Conversions should be done accurately 90% of the time. Conversions within the metric system should be done by memory.

5
ACT Discuss the difference between accuracy and precision.

COND From memory.

PL Discussion should include a clear distinction between the two terms when applied to methods of analysis; precision is a measure of reproducibility of a method, while accuracy is a measure of the error of a method.

6
ACT Define the following terms: element, compound, chemical property, physical property, homogeneous mixture, heterogeneous mixture.

COND From memory.

PL At least 5 out of 6 terms should be correctly defined.

7
ACT List four physical properties commonly used to identify pure substances.

COND From memory.

PL List should include four of the following: color, boiling point, melting point, density, solubility.

8
ACT Discuss three methods of separating pure substances from mixtures and indicate the physical property on which each is based, as well as the physical state of the various components of the mixture being separated.

COND From memory.

PL Discussion should include distillation (or fractional distillation), chromatography (paper, vapor phase), and fractional crystallization.

9
ACT Define the following terms: atom, proton, neutron, electron, nucleus, atomic number, mass number, isotope, molecule, ion.

COND From memory.

PL At least 9 out of 10 terms should be correctly defined.

10
ACT State the number of protons, electrons, and neutrons in an atom of any given element.

COND Given a periodic chart and the names of various elements.

PL Numbers should be 100% correct, including the number of neutrons in any element using the average mass number for that element.

11
ACT Perform calculations using: atomic weights, molecular weights, Avogadro's number, mole, empirical formulas, molecular formulas, specific heat, theoretical yield, percentage yield, percentage composition.

COND Given a periodic chart and appropriate data.

PL Calculations should be done using scientific notation and the answers should be rounded off to the correct number of significant digits.

12
ACT Balance simple chemical equations.

COND Given a complete, but unbalanced, chemical equation.

PL Equations should be balanced correctly 100% of the time.

13
ACT Describe what quantized energy levels mean for an atom and relate these energy levels to spectroscopy.

COND From memory.

PL Description should relate the difference in energy between the energy levels to the light emitted or absorbed in the spectrum, stating that light or energy is absorbed when the electron moves to a higher level and that light is emitted as an electron falls to a lower energy level.

14
ACT Describe the s, p, d, and f orbitals for atoms.

COND Given diagrams or models of the orbitals of various atoms.

PL Description should state that the model indicates only the most probable location of the electron around the nucleus. The number of orbitals of each type in the various shells and the maximum number of electrons which can occupy each orbital should also be stated.

15
ACT Describe the "build-up" (Aufbau) principle and use this principle to predict the electron configuration of various atoms.

COND Given a periodic chart and a list of elements.

PL Description should relate the Aufbau principle diagram to the periodic chart arrangement. Predictions should be 80% correct following the Aufbau principle. Some atoms do not follow the build-up exactly, but these differences will lead to logical errors of ± one electron and will be acceptable.

16
ACT Describe the periodicity of the elements.

COND Given a periodic chart.

PL Description should include the periodic variations in the physical and chemical properties of the elements as the atomic number increases.

17
ACT Discuss the differences between metals and nonmetals.

COND From memory.

PL Discussion should include a list of the major distinguishing characteristics of metals and nonmetals.

18
ACT Describe the following types of bonding forces and give examples of each: ionic bonding, nonpolar covalent bonding, polar covalent bonding, metallic bonding.

COND From memory.

PL Description should compare and contrast the various bonding types. The position of the elements in the periodic table should be related to the type of bond most likely to be formed and the electronic arrangement.

19
ACT Rank the elements in order of their electronegativity.

COND Given a periodic chart and a list of 4-8 elements.

PL The order F > O > Cl > N must always be correct; all others should be correct 70% of the time if no conflicting trends are given.

20
ACT Predict the ionic charges of elements.

COND Given a periodic chart and a list of elements.

PL Predictions should be 80% correct for the regular elements in simple binary compounds.

21
ACT Identify simple chemical compounds by name and chemical formula.

COND Given a periodic chart and chemical symbols *or* names for various compounds.

PL Identification should be 80% correct using common binary and ternary compounds. Special emphasis should be placed on the chemicals used in NPDES tests.

22
ACT Describe exothermic and endothermic reactions in terms of enthalpy using thermochemical equations for illustration purposes.

COND From memory.

PL Description should state that exothermic reactions are always associated with a decrease in enthalpy, while endothermic reactions are accompanied by an increase in enthalpy.

23
ACT Calculate enthalpy change (ΔH) for a reaction.

COND Given a chemical reaction and either a table of heats of formation (ΔH_f), a table of bond energies, or calorimetric data.

PL Calculations should be correct 70% of the time.

24
ACT Discuss the advantages and disadvantages of using various fuels as sources of energy.

COND Given thermochemical equations for various fuels (e.g., natural gas, wood, coal, octane, U-235).

PL Discussion should include the heating values (kcal/g) of the different fuels, as well as the time and energy it takes to make/process the fuel for use.

25
ACT Describe the kinetic molecular theory of matter.

COND From memory.

PL Description should include four of the following concepts: (1) molecules of a gas are widely separated in space, (2) they travel in straight paths, (3) they have perfectly elastic collisions, (4) they increase in average velocity with an increase in temperature, (5) all gases have the same average kinetic energy at any given temperature.

26
ACT Write the equation of state for an ideal gas, and use the equation to calculate the volume, pressure, temperature, density, or molecular weight of a gas.

COND Given all the necessary data except the value to be calculated.

PL The following equation should be written:

$$PV = nRT$$

Calculations should be correct 80% of the time.

27
ACT Discuss the differences in behavior of real gases and ideal gases.

COND From memory.

PL Discussion should mention that gases are less than ideal in behavior at high pressures and low temperatures.

28
ACT Write an equation to illustrate Graham's law and use it to relate the molecular weights of two gases to their rates of effusion.

COND Given the necessary data.

PL The following equation should be written:

$$\frac{\text{time}_A}{\text{time}_B} = \frac{\text{rate}_B}{\text{rate}_A} = \left(\frac{MW_A}{MW_B}\right)^{1/2}$$

Calculations should be done correctly 80% of the time.

29
ACT Discuss the general safety precautions which should be followed in a laboratory situation, and describe how an accident or emergency situation, such as a fire, should be handled.

COND From memory.

PL Discussion should include proper laboratory techniques and safety equipment.

30

ACT Demonstrate the following laboratory techniques: (a) density determination of solids and liquids, (b) separation of the components of a mixture using decantation, filtration, extraction, and sublimation techniques, (c) resolution of matter into pure substances by fractional crystallization and paper chromatography, (d) determination of the empirical formula for a compound, (e) calculation of percentage yield for a chemical reaction, (f) determination of the heat of reaction or neutralization, (g) determination of the order of the alkaline earth metals and halogens on the periodic table using solubilities of salts, (h) verification of the gas laws using a tightly stoppered syringe, (i) determination of the relative rates of diffusion of HCl and NH_3, (j) determination of the molecular weight of a volatile liquid using the gas laws.

COND Given a fully-equipped chemistry laboratory and laboratory procedure instruction sheets for each technique.

PL Each experiment should be done correctly 80% of the time and safely 100% of the time.

Chemistry II

PURPOSE

In this course the learner will continue to study the basic principles of chemistry and their applications. Topics to be covered include the physical states of matter, the nature of solutions, acid-base reactions, electrochemistry, rates of reaction, nuclear reactions, organic chemistry, and polymers. Laboratory exercises will demonstrate basic chemical principles and give the learner practical experience in obtaining quantitative results.

PREREQUISITES

Before beginning this course the learner should have mastered the instructional objectives for Chemistry I. This course is a prerequisite for Water/Wastewater Chemistry and Microbiology.

COURSE OUTLINE

The topics discussed in this course are listed below. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Physical States of Matter	1,2
Solutions	3-6
Rate of Chemical Reactions	7,8
Chemical Equilibrium	9-11
Acid-Base Reactions	12-17
Electrochemistry	18-21
Organic Chemistry	22-24
Nuclear Reactions	25,26
Chemical Calculations and Experiments	27-29

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the learner in understanding this subject matter, to help the instructor in gathering lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

IRIS 1321, 1322

Brown, Theodore L., and LeMay, H. Eugene, Jr. *Chemistry: the central science.* Englewood Cliffs, NJ: Prentice-Hall, 1977.

Masterton, William L., and Slowinski, Emil J. *Chemical Principles.* 4th ed., Philadelphia: W. B. Saunders Co., 1977.

Other Instructional Resources

Physical States of Matter	IRIS 1595
Solutions	IRIS 408, 481, 1509, 1595, 1791
Rate of Chemical Reactions	
Chemical Equilibrium	IRIS 949, 2120, 2121
Acid-Base Reactions	IRIS 925, 1059, 1076, 1080, 1134, 1512, 1757, 1758, 2110, 2122, 2123, 2124, 2125
Electrochemistry	IRIS 1065, 1508, 2922
Organic Chemistry	IRIS 405
Nuclear Reactions	
Chemical Calculations and Experiments	IRIS 404, 527, 538, 850, 1059, 1063, 1134, 1144, 1356, 1512, 1762, 2107, 2109, 2110, 2111, 2126, 2127, 2911, 2921, 2922 VC-4, VC-29, VC-57

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT Discuss the major distinctions between the three physical states of matter.

COND From memory.

PL Discussion should include how the distance of separation between the molecules in solids, liquids, and gases affects various characteristic properties (e.g., density, compressibility, expansibility, mobility).

2
ACT Describe the following terms using a phase diagram: sublimation, fusion, vaporization, equilibrium, critical temperature, critical pressure, triple point.

COND Given a phase diagram for a pure substance.

PL Description should include a short explanation for each term, as well as indicate the section of the phase diagram to which it relates.

3
ACT Describe the nature of solutions of solids, liquids, and gases in liquids.

COND From memory.

PL Description should include the effects of: (a) lattice energy of solids, (b) solvation energy, (c) dispersion forces, (d) entropy, (e) temperature, (f) hydrogen bonding, (g) the relationship between a saturated solution and equilibrium, (h) pressure, (i) bonding type and strength.

4
ACT Describe the nature of hydrogen bonding and its effect on the physical properties of water.

COND From memory.

PL Description should include: (a) molecular causes of hydrogen bonding, polarity, and bond angle, (b) that the resulting intermolecular forces are weaker than ionic bonding and stronger than dispersion forces, (c) effects upon the properties of water (boiling point, specific heat, heat of vaporization).

5
ACT Describe how ions are formed in solutions.

COND Given a list of both ionic and polar covalent compounds.

PL Description should include examples and explanations for both ionic and polar covalent compounds.

6
ACT Define colligative property and perform calculations for vapor pressure lowering, freezing point depression, boiling point elevation, osmotic pressure, and molecular weight of a substance using colligative property data for solutions.

COND Given the necessary data and reference materials.

PL Definition should include colligative effects of both organic and ionic compounds in solution. Calculations should be correct 80% of the time.

7
ACT Explain what data are needed to determine the rate, order, and activation energy for a given reaction (e.g., aA + bB → products).

COND Given a balanced chemical reaction.

PL Explanation should include the relationship between: (a) rate and the changes in concentration of reactants or products with respect to time, (b) order and the effect upon rate of changing the original concentrations of each reactant, (c) change in rate with temperature and the activation energy.

8
ACT Describe the effect of each of the following upon the rate of a given reaction, including the role of activation energy: temperature, bond energy of reactants and products, entropy change, concentration of reactants, catalysts.

COND Given a balanced chemical equation, a change in conditions, and an activation energy diagram.

PL Discussion should include the relationships between: (a) temperature, kinetic energy of molecules, bond strength, and activation energy; (b) molecular geometry, favorable arrangement of molecules for reaction, entropy, and reaction rate; (c) concentration and probability for a favorable collision in terms of energy and structure; (d) catalysts and activation energy.

9
ACT Define the concept of steady state, and note the difference between a steady state and an equilibrium reaction.

COND From memory.

PL Discussion should include equations which show that an equilibrium reaction involves reversible reactions, but a steady state involves reactions such as A → B → C at rates which leave B at a constant concentration.

10
ACT Predict the effect that changes in volume of system, temperature, concentration of reactants, and catalyst will have upon equilibrium.

COND Given a balanced equilibrium equation and a set of conditions, including whether the reaction is exothermic or endothermic and the physical state of each of the reactants and products.

PL Predictions should be correct 80% of the time.

11
ACT Write the equilibrium constant (K_c) expression and calculate the equilibrium constant, the extent of reaction, or the concentration of any reactant or product for a chemical reaction.

COND Given a balanced reversible chemical equation and the necessary data to do one of the above calculations.

PL Written expression should include that the concentration of a solid is equal to unity. Calculations should be correct 75% of the time.

12
ACT Discuss the dissociation of water and how it relates to pH and the nature of acids and bases.

COND From memory.

PL Discussion should include the equation and the equilibrium constant (K_w) expression for the dissociation of water, the numerical value of K_w, the definition of pH, and the relationships between $[H^+]$, $[OH^-]$, and pH in aqueous solutions.

13
ACT Select the strongest acid or base from a group.

COND Given a periodic chart and a list of acids or bases.

PL Selections should be made separately from binary and ternary acids with 80% accuracy within each list.

14
ACT Select the Brønsted acid and Brønsted base in an acid-base reaction.

COND Given the equation for an acid-base reaction.

PL Selection should be correct 80% of the time.

15
ACT Draw generalized titration curves, write net ionic equations, and choose appropriate indicators for the following acid-base reactions: strong acid-strong base; strong acid-weak base; weak acid-strong base.

COND Given formulas for the acids and bases.

PL Drawings, equations, and choice of indicators should be correct 80% of the time.

16
ACT Relate titration data for an acid-base reaction to 1) the concentration of an acid or a base in solution or 2) the gram equivalent weight of solid acid.

COND Given the necessary titration data.

PL Calculations should be done correctly 80% of the time.

17
ACT Describe in general terms how to make a buffer solution and give a specific example to show (using equations) how buffer solutions prevent drastic changes in pH.

COND From memory.

PL Description should state that a buffer solution contains a mixture of a weak acid and its conjugate base and include the reactions which occur due to the addition of a strong acid or a strong base.

18
ACT Differentiate between ionic charge and oxidation state.

COND From memory.

PL Discussion should include definitions of the two terms and point out their differences.

19
ACT Determine the oxidation state of each element in an ion or molecule.

COND Given a periodic chart and a list of formulas of ions and molecules.

PL Determination of oxidation states of the elements should be correct 85% of the time.

20
ACT Balance redox equations.

COND Given a periodic chart, a complete but unbalanced chemical equation, and either basic or acidic conditions.

PL Equations should be balanced correctly 70% of the time.

21
ACT Sketch electrolytic and voltaic cells corresponding to a given redox reaction.

COND Given a table of reduction (or oxidation) potentials.

PL Sketch of cell should include: (a) direction of electron flow, (b) half-reaction taking place at each electrode, (c) movement of anions and cations within the cell (and when present the salt bridge), voltage produced (for voltaic cells only).

22
ACT Classify, name, or draw structural formulas for the following types of organic compounds: aliphatic hydrocarbons, aromatic hydrocarbons, alcohols, acids, esters, ethers, aldehydes, ketones, amines, amino acids, halogenated hydrocarbons, organic phosphates.

COND Given the name or formula of several organic compounds.

PL Identification should be accurate 75% of the time.

23
ACT Name (or draw structural formulas for) structural isomers and geometric isomers.

COND Given structure (or name) of the organic compound.

PL Name or structure should be correct 75% of the time.

24
ACT Describe preparation and general properties of polymers.

COND Given monomers for both addition and condensation polymers.

PL Description should include sketch of a portion of the polymer.

25
ACT Complete and balance nuclear reactions illustrating alpha, beta, and gamma radiation.

COND Given the equation with only one reactant or product missing and a periodic chart.

PL Equations should show the symbol, atomic number, and atomic weight of the unknown species.

26
ACT Describe the processes of nuclear fission and nuclear fusion.

COND Given reference materials.

PL Description should include the requirements relating to the nucleus for both fusion and fission.

27
ACT Perform calculations using the following: (a) specific heat, (b) heat of fusion, (c) heat of vaporization, (d) equivalent weights (for acids, bases, and metals), (e) weight percentage, (f) mole fraction, (g) molarity, (h) molality, (i) normality, (j) parts per million (ppm), (k) pH, $[H^+]$, $[OH^-]$, (l) ionization constants for weak acids and bases.

COND Given a periodic chart and the necessary data.

PL Calculations should be done correctly 80% of the time.

27
ACT Demonstrate the use of the following equipment: Spectronic 20 spectrophotometer, pH meter, electrolysis apparatus, gas chromatograph, atomic absorption spectrophotometer.

COND Given the above equipment with appropriate operating manuals.

PL Demonstration should show correct usage and safe handling of each piece of equipment.

29

ACT Perform the following laboratory techniques: (a) determination of the solubility of a gas and a solid in a liquid, (b) determination of molecular weight of a substance by freezing point depression, (c) study the rate properties of a chemical reaction as varied by concentration of reactants, temperature, and presence of a catalyst, (d) determination of the gram equivalent weight of a solid acid, (e) analysis of acid or base solutions using titration techniques, (f) determination of a gram equivalent weight by electrolysis, (g) determination of the concentration of a cation (e.g., Cu^{3+}) using colorimetric techniques and atomic absorption, (h) determination of the half-life of a radioactive isotope, (i) demonstration of organic structures using molecular models, (j) analysis of a mixture of organic compounds (e.g., gasoline) using gas chromatography.

COND Given a fully-equipped chemistry laboratory and instruction sheets for each technique.

PL Each experiment should be done correctly 80% of the time and safely 100% of the time.

Water/Waste Water Chemistry and Microbiology (Lecture)

PURPOSE

In this course the learner will study the basic principles of microbiology and chemistry as they relate to water quality control. Considerable emphasis is placed on interpretation of analytical data from water quality tests used in water supply, wastewater treatment, and stream pollution surveys.

PREREQUISITES

Before beginning this course the learner should have mastered the instructional objectives for Biology and Chemistry II. This course is designed to be taken concurrently with Water/Wastewater Chemistry and Microbiology (Laboratory).

COURSE OUTLINE

The topics covered in this course are listed below. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number (s)
Types of Microorganisms	1,2
Cell Function and Growth	3-7
Waterborne Microorganisms and Disease	8,9
Indicator Organisms	10,11
Residues	12
Alkalinity, Acidity, and pH	13
Hardness	14
Dissolved Oxygen	15,16
Biochemical Oxygen Demand	17-19
Quantitative Analytical Methods	20

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the student in learning this subject matter, to help instructors in gathering lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

IRIS 4, 465, 1039, 2025, 2361, 2880

Other Instructional Resources

Types of Microorganisms	
Cell Function and Growth	VC-153.1
Waterborne Microorganisms and Disease	IRIS 459, 743
Indicator Organisms	IRIS 1767, 1833 VC-26, VC-153.1
Residues	IRIS 902, 1370, 2559
Alkalinity, Acidity, and pH	IRIS 289, 413, 466, 481, 488, 1027, 1076, 1080 XT-66
Hardness	IRIS 289, 488, 1075, 1363, 1513, 2575
Dissolved Oxygen	IRIS 408, 488, 1024, 1834
Biochemical Oxygen Demand	IRIS 539, 852, 876, 955, 1348, 1729 XT-59
Quantitative Analytical Methods	IRIS 142, 481, 488, 671, 699, 1239, 1240, 1759, 1782, 2221, 2407, 2558, 2559

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT List four characteristics of procaryotes and name at least two phyla of procaryotes.

COND From memory.

PL List of characteristics should include the following: carry on all functions of living things, have no organized system of membranes, have little internal organization, have no mitochondria, plastids, or complex flagella.

2
ACT Describe the differences between procaryotes and eucaryotes and give at least two examples of each.

COND From memory.

PL Description should mention that eucaryotes are more complex than procaryotes and include the structural differences occurring in the cell wall, nuclear body, DNA arrangement, and sexual reproduction.

3
ACT Describe the following types of organisms in terms of their nutritional and energy sources: heterotrophs, saprophytes, parasites, autotrophs, holophytes, chemotrophic autotrophs, phototrophic autotrophs, mixotrophs.

COND From memory.

PL At least 6 of the 8 terms should be correctly defined.

4
ACT Name and describe the three major types of respiration of microorganisms.

COND From memory.

PL The following types of respiration should be accurately described: aerobic, anaerobic, facultative.

5
ACT Draw a typical growth curve for a bacterial population and label the various growth phases.

COND From memory.

PL Drawing should have the lag, exponential, stationary, and death phases labelled.

6
ACT Describe the effects on the various parts of the bacterial growth curve of the following phenomena exhibited by two different types of bacterial cells growing together in the same culture: antagonism, symbiosis, synergism.

COND From memory.

PL Description should include a growth curve and apply each phenomena effect to the particular growth phases on the curve.

7
ACT Describe the microbiology of sewage, potable water, and receiving waters.

COND From memory.

PL Description should include typical numbers of usual enteric bacteria and the role of bacteria as mediators for chemical transformations in the carbon and nitrogen cycles.

8
ACT Describe in general terms the agents of food-borne and water-borne disease.

COND Given reference materials.

PL Description should include examples of diseases caused by bacteria, protozoa, and viruses and a discussion of the fecal-oral route.

9
ACT Discuss the advantages and disadvantages of various enteric organisms as potential indicator organisms.

COND From memory.

PL Discussion should describe why pathogenic organisms are unsatisfactory as indicators and include the following organisms: bacteroides, *Lactobacillus, Enterobacter aerogenes, Escherichia coli, Streptococcus faecalis.*

10
ACT Analyze indicator organism data.

COND Given the necessary data.

PL Analysis should include the importance of the ratio of total coliform to *Enterobacter aerogenes* to fecal coliform to fecal streptococci.

11
ACT Describe the interrelationships between the various types of residue (filterable, non-filterable, total, volatile, fixed) found in water and wastewater.

COND Given class lecture notes and reference materials.

PL Description should include physical nature of filterable, non-filterable, total, volatile, and fixed residues. The filterable residue should be related to turbidity and conductivity; the non-filterable residue to suspended and settleable solids; the volatile fraction to the organic content; and the fixed fraction to the mineral content. Reference should also be made to true versus apparent color.

12
ACT Discuss the interrelationship of pH, acidity, and alkalinity in natural waters as well as treated water and wastewater.

COND Given class lecture notes and reference materials.

PL Discussion should include the types and sources of ions which act as buffers in various waters, a titration curve for a hydroxide-carbonate mixture, and a graphical representation of titration of samples containing various forms of alkalinity.

13
ACT Discuss the cause and sources of hardness in water.

COND Given class lecture notes and reference materials.

PL Discussion should include both carbonate and non-carbonate hardness.

14
ACT Describe the laws relating to the solubility of oxygen in water.

COND Given class lecture notes and reference materials.

PL Description should include effects on solubility due to pressure (Henry's law) and dissolved particles (Raoult's law).

15
ACT Explain the environmental significance of oxygen dissolved in water.

COND Given class lecture notes and reference materials.

PL Explanation should include its role in aerobic stream purification, aerobic wastewater treatment, and aerobic organism prevalence.

16
ACT Define biochemical oxygen demand (BOD) and discuss the variables that affect the BOD.

COND Given class lecture notes and reference materials.

PL Definition should include that it is oxygen consumed by microorganisms during stabilization of organic matter. Discussion should include the detailed effects of time, temperature, toxicity, organism type, acclimation, nitrification, and dissolved oxygen.

17
ACT Derive the first order equation for the kinetic rate of BOD.

COND From memory.

PL The following equation should be given:

$$y = L(1 - 10^{-kt})$$

18
ACT Explain the relationship of theoretical oxygen demand to BOD and chemical oxygen demand (COD).

COND From memory.

PL Explanation should include the basic parameters which each measurement includes or excludes.

19
ACT Describe in detail the preferred method for analysis of the parameters listed in Appendix B. (See laboratory section, page 39).

COND Given class lecture notes.

PL Description should include the appropriate chemical reactions, reagents, and key conditions under which the analysis is carried out.

Water/Waste Water Chemistry and Microbiology (Laboratory)

PURPOSE

In this course the learner will perform the various analytical techniques used in microbiology and chemistry and in water quality control. The student will learn proper sampling and preservation techniques, as well as how to recognize and recheck abnormal results in the analytical procedures. Safety in the laboratory and technical report writing will also be emphasized.

PREREQUISITES

Before beginning this course, the learner should have mastered the instructional objectives for Chemistry II, Technical Writing, and Biology. This course is designed to be taken concurrently with Water/Wastewater Chemistry and Microbiology (Lecture).

COURSE OUTLINE

The topics covered in this course are listed below. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Use of Equipment	1
Sampling Procedures	2,3
General Microbiological Techniques	4-7
Microbiological Analyses	8,9
Chemical Analyses	10
Laboratory Reports	11

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the student in learning this subject matter, to help instructors in gathering lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

IRIS 4, 129, 142, 465, 488, 699, 1039, 1152, 1324, 1370, 1782, 2025, 2221, 2407, 2558, 2559

Other Instructional Resources

Use of Equipment	IRIS 1357, 1414, 2911 MP-25, VC-8, VC-26
Sampling Procedures	IRIS 833, 879, 1325, 2158
General Microbiological Techniques	IRIS 1352, 1364, 1365, 1366, 1367, 1368, 1980 2158
Microbiological Analyses*	IRIS 426, 1415, 1626, 1628, 1767, 1980 MP-19
Chemical/Analytical Techniques**	IRIS 866, 931, 1125, 1461, 1473 VC-12, VC-13
Laboratory Reports	IRIS 225, 387, 833, 879, 1047

*for additional instructional resources see page 38.
**for additional instructional resources see page 40.

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT Demonstrate the correct usage of the following pieces of laboratory equipment: standard microscope, oil immersion microscope, binocular dissecting microscope, autoclave, dry heat sterilizing oven, membrane filtration apparatus, bacteriological glassware, water bath.

COND Given the equipment listed above, access to a fully-equipped microbiology laboratory, and an operating manual for each piece of equipment.

PL Demonstration should include correct usage and safe handling of each piece of equipment.

2
ACT Describe and demonstrate the procedure for preparing containers for collecting samples for each of the wastewater analyses listed in Appendix A and B (pages 38 and 39).

COND Given the necessary containers and other equipment, reference materials, and instructions for preparing the containers.

PL At least 90% of the containers should meet the specifications in one of the references.

3
ACT Describe and demonstrate the procedure for collecting, transporting, and storing samples for any of the wastewater analyses listed in Appendix A and B (pages 38 and 39).

PL At least 90% of the procedures should meet the specifications in one of the references.

4
ACT Perform aseptically the following techniques using proper safety precautions: serial dilution, pouring agar plates, streaking agar slants and plates, making total counts, transferring aseptically with a loop, preparing culture media, counting colonies.

COND Given agar for culturing bacteria, a sample of wastewater, access to a fully-equipped microbiology laboratory, and instructions for performing each technique.

PL Each technique should be performed successfully and free of outside contamination 90% of the time.

5
ACT Perform gram and other differential staining procedures on bacteria cultures.

COND Given the bacteria cultures, the necessary laboratory equipment and reagents, and instructions for performing the staining procedures.

PL Student should demonstrate proper procedure to the instructor.

6
ACT Isolate in pure culture an unknown bacteria from a sample of wastewater using a pour plate technique.

COND Given a sample of wastewater, the necessary laboratory equipment and culturing media, and instructions for isolating and culturing bacteria. Student will need to take several lab sessions to do this task.

PL Student should demonstrate the isolation of a pure strain or organism after making several transfers.

7
ACT Perform the standard plate count on each of the following types of water samples: sample of fresh water from stream; sample of untreated wastewater; sample of treated, unchlorinated wastewater; sample of treated, chlorinated wastewater.

COND Given four samples of fresh water and wastewater, the necessary laboratory equipment, and instructions for doing the standard plate count technique.

PL For each sample, the range of the count for three replicates should be within ±20% of the mean obtained by the instructor.

8
ACT Perform total coliform, fecal coliform, and fecal streptococci tests using the multiple-tube fermentation technic.

COND Given samples of stream water, access to a fully-equipped microbiology laboratory, and instructions for performing the multiple-tube fermentation technic.

PL Most probable numbers (MPN) found from three replicate samples should be within ±20% of the MPN obtained by the instructor.

9
ACT Perform total coliform, fecal coliform, and fecal streptococci tests using the membrane filtration method.

COND Given samples of stream water, access to a fully-equipped microbiology laboratory, and instructions for performing the membrane filtration technic.

PL MPN's found from three replicate samples should be within ±20% of the MPN obtained by the instructor.

10
ACT Perform each of the chemical analyses listed in Appendix B (page 39) following proper safety procedures.

COND Given the necessary equipment and chemicals, samples of wastewater, and instructions for performing each analysis.

PL Sample results should fall within ±20% of the value obtained by the instructor.

11
ACT Prepare a report for each of the microbiological and chemical analyses listed in Appendix A and B (pages 38 and 39). The report should include the following:

1. title page
2. table of contents
3. purpose
4. list of materials and equipment
5. procedures
6. results (sample calculations, graphs, data tables)
7. discussion
    a. historical significance
    b. application
    c. chemical reaction involved
    d. comparison of results with typical values
    e. possible sources of error
    f. alternative methods of performing the analysis
8. references
9. appendix (raw data, lab handouts)

COND Given data obtained in laboratory analyses performed in ACT's 7, 8, 9 and 10, reference materials containing the charts, nomographs and standard curves necessary to analyze the data, and a calculator.

PL At least 90% of the results of the analyses should be correctly interpreted. When abnormal results are identified, suggestions for corrective procedures to recheck results should be given.

Appendix A – Microbiological Analyses

This course is concerned with the following microbiological analyses:

Total plate count

Total coliform

Fecal coliform

Fecal streptococci

Additional Instructional Resources

In addition to the resources listed in the introduction to this course, the following resources are also useful in performing microbiological analyses.

IRIS 142, 426, 1152, 1324, 1370, 1414, 1619, 1620, 1621, 1624, 1626, 1628, 1629, 1833, 2558, 2559

MP-19, VC-12, VC-13, VC-81, VC-162.1, VC-162.2, VC-162.3, VC-162.4

Appendix B – Chemical Analyses

This course is concerned with the following chemical analyses:

Biochemical oxygen demand (BOD_5)

Dissolved oxygen (DO)

Chemical oxygen demand (COD)

Filterable residue

Non-filterable residue

Total residue

Volatile residue

Fixed residue

Settleable residue

Turbidity

Color

Chlorine residual

Kjeldahl nitrogen

Ammonia

Nitrite/Nitrate

Orthophosphate

Total phosphorous

pH

Acidity

Alkalinity

Hardness

Volatile acids

Additional Instructional Resources

In addition to the resources listed in the introduction to this course, the following resources pertain to the individual water/wastewater analyses listed below.

Biochemical oxygen demand (BOD_5)	IRIS 1343, 1348, 1349, 1350, 1351 OT-2, VC-40, VC-152.3, XT-54
Dissolved oxygen (DO)	IRIS 488, 540, 1351 VC-5, VC-38, VC-41, VC-152.3
Chemical oxygen demand (COD)	IRIS 539, 557, 1343, 1729 VC-6
Filterable residue, Non-filterable residue, Total residue, Volatile residue, Fixed residue, Settleable residue	IRIS 289, 902, 1079, 1345, 1346, 1623, 1627 VC-21, VC-42, X-28, XT-57
Turbidity	IRIS 1078, 1347
Color	IRIS 1078
Chlorine residual	IRIS 472, 556, 700, 1078, 1079, 1787, 1980 XT-93
Kjeldahl nitrogen	IRIS 1025
Ammonia	IRIS 467, 488, 1079
Nitrite/Nitrate	IRIS 480, 1079, 1343 VC-58
Orthophosphate	IRIS 542, 1343
Total phosphorous	IRIS 480, 542, 1079, 1343
pH	IRIS 289, 1027, 1076
Acidity	IRIS 1076
Alkalinity	IRIS 289, 413, 466, 1027, 1079 VC-152.2
Hardness	IRIS 289, 1075, 1363
Volatile acids	IRIS 142, 185

Engineering Surveys

PURPOSE

In this course the learner will continue to study the basic techniques of surveying. Applications to field work in hydrographic and photogrammetric surveys will be given. Proper field procedure, minimal error, and accurate notekeeping are stressed throughout the course.

PREREQUISITES

Before beginning this course, the learner should have mastered the instructional objectives for Elementary Surveying. This course is a prerequisite for Water Quality Management Internship.

COURSE OUTLINE

The following topic are covered in this course. The numbers of the various instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Construction Surveys	1
Circular, Spiral, and Parabolic Curves	2-4
Volumes, Dam, and Reservoir Surveys	5-7
Hydrographic Surveys	8-14
Floodplain Delineation	15
Photogrammetric Surveys	16-27

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the student in learning this subject matter, to help instructors gather lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

Bouchard, Harry, and Moffitt, Francis H. *Surveying*, 5th ed. Scranton, PA: International Textbook Co., 1965.

Brinker, Russell C., and Wolf, Paul R. *Elementary Surveying*. New York: Thomas Y. Crowell Co., 1977.

Davis, Raymond E., Foote, Francis S., and Kelly, Joe W. *Surveying: Theory and Practice*. New York: McGraw-Hill, 1968.

Kissam, Philip. *Surveying Practice*. New York: McGraw-Hill, 1971.

Other Instructional Resources

Construction Surveys	
Circular, Spiral, and Parabolic Curves	
Volumes, Dam, and Reservoir Surveys	
Hydrographic Surveys	IRIS 491, 618, 879, 1081, 1756, 1768, 1831, 2559, 2758, 2759
Floodplain Delineation	
Photogrammetric Surveys	IRIS 1755, 1756, 1831

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT Explain how stakes are set during earth excavation work for construction of a) pipe lines, b) irrigation channels, c) buildings, and d) culverts with flared wing walls.

COND From memory.

PL Explanation should include techniques of both batter board and laser beam.

2
ACT Make the necessary calculations for staking out a circular curve for an irrigation channel using 100 ft. stations and stake out this curve on the field.

COND Given deflection angle, degree of curve, chainage of beginning of the curve, a transit, and a tape.

PL Calculations and stake out should be done to the nearest second.

3
ACT Make the necessary calculations for an addition of transition curves (spirals) of length 250 ft. at each end of the circular curve and stake out the complete curve using 50 ft. stations.

COND Given deflection angle, degree of curve, chainage of beginning of the curve, a transit, and a tape.

PL Calculations and stake out should be done to the nearest second.

4
ACT Calculate the elevations of the stations on a vertical curve and locate the point on the curve where the depth of cutting is maximum.

COND Given an intersection point, chainage of two grades, elevation of the intersection point, and length of the vertical curve.

PL Calculations should be accurately performed.

5
ACT Describe the three methods of computing the volume of earthwork involved in the construction of a channel or road excavation work.

COND Given reference materials and the following types of field conditions: 1) level section, 2) two-level section, 3) side hill, two-level section, 4) three-level section, 5) multi-level section.

PL Description should include cross section method by coordinates, cross-section method by matrix, and borrow-pit method.

6
ACT Compute the capacity of a reservoir and the volume of earthwork for the reservoir dam.

COND Given the necessary data.

PL Computations should be done using the contour-area method for reservoir capacity and the cross-section method for volume of earthwork.

7
ACT Discuss the usefulness of a mass diagram in earthwork and plot a mass diagram.

COND Given the necessary data.

PL Discussion should include a detailed sketch.

8
ACT Discuss hydrographic surveying, give examples, and explain how horizontal control and vertical control is established in this type of surveying.

COND From memory.

PL Explanation should include that horizontal control is provided by two or more points on the ground accurately fixed in position by distance and direction and vertical control is provided by two or more benchmarks which are in or near the area to be surveyed.

9
ACT Define the term *sounding*, state the equipment and personnel necessary for locating soundings, describe how they are taken, and explain briefly the various methods of locating soundings in river surveys.

COND From memory.

PL Explanation should include the following methods of locating soundings: 1) by transit and stadia, 2) by range and time intervals, 3) by range and one angle from shore, 4) by range and one angle from boat, 5) by two angles from shore, 6) by two angles from boat, 7) by intersecting ranges, 8) by distances along a wire or rope stretched across a stream between stations, and 9) by cross rope.

10
ACT Describe how to plot the position of the sounding boat P while making a hydrographic survey.

COND Given points A, B, and C on the shore and the angles APB and BPC measured with a sextant.

PL Description should include mechanical (station pointer) and graphical methods.

11
ACT Describe the different methods of measuring the discharge of a stream at a given site and state the important factors to consider in selecting a stream gaging site.

COND From memory.

PL Description should include use of current meter, weirs, and Parshall flume.

12
ACT Discuss the different type of water-stage recording instruments and how to measure and plot a cross-section of a stream.

COND From memory.

PL Discussion should include the following instruments: crest-stage gage, wire-weight gage, staff gage, hook gage, recording gage, continuous strip-chart recorder, digital recorder.

13
ACT Describe various techniques and instruments for measuring velocity at a gaging station.

COND From memory.

PL Description should include a current meter, floats, and chemical methods.

14
ACT Conduct a stream gaging operation for a shallow creek, prepare typical field notes, and calculate the discharge.

COND Given a shallow stream site, measuring rod, current meter, and fieldbook.

PL Calculation of total discharge should be done by summation of partial discharges of each section.

15
ACT Conduct the necessary field survey and prepare a flood plain map for a small creek.

COND Given a small creek site, a 100-year frequency flood elevation, a transit, pins, a rod, and a tape.

PL Survey should include a search and location of a number of points by trial and error (direct contouring) on the required 100-year flood elevation contour. Mapping should be completed using the stadia survey method.

16
ACT Define photogrammetry and discuss two major areas which it encompasses.

COND From memory.

PL Discussion should include 1) determination of horizontal distances, elevations, and compilation of mosaics and topographic maps and 2) photographic interpretation.

17
ACT Discuss two types of basic photographs used in photogrammetry, including the instruments used to obtain the photographs.

COND From memory.

PL Discussion should include aerial and terrestrial photographs as the basic types of photographs used in photogrammetry, and aerial camera and phototheodolite as instruments used to obtain them.

18
ACT Discuss the advantages of using photographic instruments rather than transit-stadia or plane table methods.

COND From memory.

PL Discussion should include increased detail, speed, low cost, and reduced likelihood of omitting data.

19
ACT Determine the photoscale of a photograph.

COND Given either 1) the focal length of camera, the flying height above mean sea level, and the elevation of a point on the ground or 2) the photodistance between two well-defined objects, the map distance between these two points, and the map scale.

PL Determination should be done using the following equations:

$$s = \frac{f}{H\text{-}h_a} \quad \text{(used for conditions 1 only)}$$

$$\text{photoscale} = \frac{\text{photo distance}}{\text{map distance}} \times \text{map scale}$$

20
ACT Determine the ground coordinates of points from a vertical photograph and use them to calculate horizontal distances and horizontal angles.

COND Given reference materials.

PL Determinations should be done using the following equations:

$$X_A = \frac{H\text{-}h_A}{f} x_a \qquad X_B = \frac{H\text{-}h_B}{f} x_b$$

$$Y_A = \frac{H\text{-}h_A}{f} y_a \qquad Y_B = \frac{H\text{-}h_B}{f} y_b$$

$$AB = \sqrt{(X_B - X_A)^2 + (Y_B - Y_A)^2}$$

$$\text{Angle AOB} = \tan^{-1}\left(\frac{X_A}{Y_A}\right) + \tan^{-1}\left(\frac{Y_B}{X_B}\right) + 90^\circ$$

21
ACT Explain the term relief displacement as used with vertical photographs.

COND From memory.

PL Explanation should include a sketch and the formula $d = \frac{rh}{H'}$.

22
ACT Determine the flying height of a vertical photograph.

COND Given reference materials and either 1) a line of known length on a fairly level terrain which appears on a photograph and the focal length of the camera, or 2) the image of two ground control points A and B which appear on a vertical photograph.

PL Determination should be done using the following equations:

for conditions 1 $\quad \text{scale} = \frac{f}{H}$

for conditions 2

$$L^2 = \left[\frac{(H-h_B)\,x_b - (H-h_a)\,x_a^2}{f}\right] + \left[\frac{(H-h_B)\,y_b - (H-h_A)\,y_a^2}{f}\right]$$

23
ACT Define parallax, describe how to use it to find the parallax of a point, and describe how you would calculate ground coordinates using parallax equations.

COND Given reference materials.

PL Description should include use of $p = x - x_1$ to find the parallax of a point and the equations

$$X = \frac{B}{p}x \text{ and } Y = \frac{B}{p}y$$

for calculating ground coordinates.

24
ACT Describe stereoscopic viewing of photographs, including how stereoscopic plotters can be used to compile topographic maps.

COND From memory.

PL Description should include the basic components of plotters (projection, viewing, measuring, tracing) which make possible an optical-mechanical solution of the parallax equations.

25
ACT Prepare a flight plan to prepare a topographic map.

COND Given the area, mean sea level of average terrain, airplane speed, focal length of camera, end lap, side lap, and required scale of photography.

PL Plan should include the flying height, distance between exposures, intervalometer setting, total number of photographs per flight line, distance between flight lines, number of flight lines, and total number of photographs required.

26
ACT List sources of error and mistakes which occur in photogrammetry.

COND From memory.

PL List should include at least six sources of error and five types of mistakes.

27
ACT Discuss the latest advancements in technology related to surveying.

COND From memory.

PL Discussion should include changes in technology affecting aerial reconnaissance, as well as remote sensing.

Environmental Sanitation

PURPOSE

The purpose of this course is to introduce the learner to the wide range of issues involved in environmental control. Management of food, insects, rodents, air and water resources, solid wastes, toxic substances, wastewaters, and radiation are discussed. The complexity and multidisciplinary nature of environmental problems are emphasized. Historical and modern-day methods of environmental protection are discussed as well as current governmental rules and regulations.

PREREQUISITES

Before beginning this course the learner should have mastered the instructional objectives for Biology, Chemistry I, and Physics I. This course is a prerequisite for Water Pollution Abatement and Water Quality Management.

COURSE OUTLINE

The topics covered in this course are listed below. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Environmental Health Sciences	
1) Epidemiology	1-7
2) Toxicology	8-11
3) Occupational Health and Safety	11
4) Radiation Health and Safety	12-14
Vector Control	15
Food Protection	16,17
Air Resources and Pollution Control	18-24
Water Resources and Pollution Control	24-32
Solid Waste Management	33-35
Environmental Interrelations	36-43

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the learner in understanding this subject matter, to help the instructor in gathering lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

IRIS 1728, 1737, 2051, 2052, 2053, 2054, 2058, 2377, 2391

Other Instructional Resources

Environmental Health Sciences

1) Epidemiology	IRIS 580, 1005, 1150, 1434, 1435, 1643, 2049, 2880
2) Toxicology	IRIS 1444, 1835
3) Occupational Health and Safety	IRIS 1030, 1150
4) Radiation Health and Safety	IRIS 614, 615, 616, 617, 1150
Vector Control	IRIS 1150
Food Protection	IRIS 1150, 1130, 1440
Air Resources and Pollution Control	IRIS 1088, 1150, 1283, 1444, 1931
Water Resources and Pollution Control	IRIS 3, 164, 178, 459, 463, 479, 733, 742, 743, 761, 770, 801, 1000, 1088, 1102, 1157, 1283, 1446, 1815, 1931, 2915 MP-17
Solid Waste Management	IRIS 1088, 1150, 1931, 2203 VC-15
Environmental Interrelations	IRIS 159, 163, 401, 481, 482, 566, 578, 579, 580, 737, 844, 1014, 1081, 1096, 1107, 1121, 1273, 1284, 1285, 1296, 1297, 1407, 1509, 1665, 1727, 1830, 2049, 2051, 2052, 2261, 2266, 2267, 2276, 2277, 2281, 2404, 2713, 2818, 2882, 2919

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT Define the following terms: host, vector, reservoir, parasite, etiological agent, epidemiology, toxicology, health, virulence, illness, pathogenicity, epidemic, endemic, communicable disease, enteric, fecal/oral route, chronic disease.

COND From memory.

PL At least 15 of the 17 terms should be correctly defined.

2
ACT Name four types of etiological agents responsible for communicable diseases, describe how they are transmitted by both direct (3) and indirect (5) means, and describe factors which affect their transmission.

COND From memory.

PL Description should include various types of etiological agents, examples of diseases they cause, how they are transferred, and factors which affect transmission.

3
ACT Identify communicable diseases transmitted by various vectors and causative agents.

COND Given a list of communicable diseases, a list of vectors, and a list of causative agents.

PL Identification should include diseases transmitted by milk, food, and shellfish.

4
ACT Describe three general methods of controlling communicable diseases.

COND From memory.

PL Description should include three of the following methods and an explanation of how they are used to control communicable diseases: immunization, vector control, isolation and quarantine, food sanitation, and water sanitation.

5
ACT List and describe the various types of vital statistics.

COND From memory.

PL Description should include statistics such as morbidity rates and mortality rates, where this data may be obtained, and an explanation of how the data can be used by an environmental protection specialist.

6
ACT Discuss in essay form population growth and its impact on environmental quality.

COND Given reference materials.

PL Discussion should include historical growth of the human population worldwide and in the United States, its effect on rate of utilization of natural resources, amount of reserves of natural resources, methods of controlling population growth, and the effect of population increases on man's health, comfort, and the balance of ecosystems.

7
ACT Predict the future population of a community.

COND Given population data, pertinent historical information, and appropriate formulas.

PL Prediction should be done correctly.

8
ACT Define the following terms: TLV, LD_{50}, LC_{50}, carcinogen, synergistic effect, antagonistic effect, toxic material, acute toxicity, chronic toxicity.

COND From memory.

PL At least 7 of the 9 terms should be correctly defined.

9
ACT Describe six factors which affect man's reaction to toxic materials.

COND From memory.

PL Description should include six of the following: chemical structure of the material, particle size, solubility of the material, surface area, nutrition of individual, duration of exposure, individual susceptibility, concentration of chemical, presence of other substances.

10
ACT List four routes of entry of toxic materials into the human body and describe the types of physiological responses which are elicited.

COND From memory.

PL List should include the following routes: skin, lungs, mouth, eyes. Description should include the types of responses occurring at the various cellular levels.

11
ACT Evaluate data generated from a disease outbreak or occupational health investigation.

COND Given background information, methodology, and data collected from epidemiological or toxicological study with the appropriate statistics performed.

PL Evaluation should include a critique of the procedures used in the study, the validity of the data, the significance of the statistics, a summary of the overall results, and suggestions as to a course of action.

12
ACT Define the following terms: curie, roentgen, rad, rem, radionuclides, isotype, RBE, critical organ, half-life, radiation, alpha particles, beta particles, gamma rays, X-rays.

COND From memory.

PL At least 10 of the 14 terms should be correctly defined.

13
ACT Describe the relative hazards of various radioactive particles.

COND Given a list of radioactive particles.

PL Description should include how to shield a worker from the various particles.

14
ACT Describe acute and delayed radiation effects on the human body.

COND From memory.

PL Description should include the acute radiation effects on the blood system, gastrointestinal tract, and central nervous system, as well as the diseases and physical conditions incurred by external exposure over extended time periods.

15
ACT Using the mosquito and rat as examples, discuss in essay form the advantages and disadvantages of natural and chemical types of vector control and their resulting effects on environmental problems.

COND Given life cycle diagrams of the mosquito and the rat and ecological information regarding breeding cycles, feeding habits, range of movement, and habitat.

PL Discussion should include biological control methods, use of various kinds of insecticides at the different stages of development, and the effect of these control methods on water, air, and land use.

16
ACT Describe the primary targets of food protection and discuss how various methods of food (2), shellfish (1), and milk (2) sanitation protect man's food supply.

COND From memory.

PL Description should include at least three considerations (e.g., animal parasites, microorganisms, bacterial toxins, use of harmful additives) involved in food protection and how they are implemented using the various methods of food sanitation.

17
ACT Discuss the relationship of food poisoning to water-borne communicable diseases.

COND From memory.

PL Discussion should include methods of disease transfer which involve use of both food and water.

18
ACT Define the following terms: emissions inventory, air pollution standards, air pollution criteria, photochemical smog.

COND From memory.

PL At least 3 of the 4 terms should be correctly defined.

19
ACT List five primary air pollutants and major manmade (4) and natural (1) sources of these pollutants.

COND From memory.

PL List should include hydrocarbons, particulates, carbon monoxide, nitrogen oxides, and sulfur oxides as the primary air pollutants, and transportation, fuel combustion (stationary sources), industrial processes, solid waste disposal, and forest fires as the sources of air pollutants.

20
ACT Describe control techniques used to remove gases (3) and particulates (4) from the air and indicate their removal efficiency.

COND From memory.

PL Description should include the stated number of the following techniques:

for gases process modification, absorption, adsorption, combustion/oxidation, condensation.

for particulates settling chambers, cyclones, scrubbers, fabric filters, electrostatic precipitators.

The relative efficiency of the method to remove pollutants should also be noted.

21
ACT Define the following general types of air pollution sources and give an example of each: point, line, area, instantaneous, continuous.

COND From memory.

PL At least 4 of the 5 terms should be correctly defined.

22
ACT Describe the types and causes of inversions and their relationship to air pollution episodes.

COND From memory.

PL Description should include the various types of inversions and how they affect the dispersion of air pollutants, as well as temperature profiles showing the standard atmospheric lapse rate, a radiation inversion, and a subsidence inversion.

23
ACT Describe the fate of gases and various size particulates in the human respiratory system.

COND Given a diagram of the human respiratory system with the following components labelled: nasal passages, trachea, bronchia, and alveoli. Given the following particle sizes:
$> 10\mu$, 2 - 10μ, 2 - 0.1μ, 0.1μ.

PL Description should include the fate of soluble gases, gases absorbed in particulates, and particles of various sizes, as well as various defense mechanisms used in the human body to remove air pollutants.

24
ACT Discuss in essay form the history of water treatment and air pollution control practices with references to various environmental conditions which necessitated a change in waste disposal practices.

COND Given reference materials.

PL Discussion should include historical methods of environmental control and how they evolved to the present-day methods.

25
ACT Define the following terms: primary treatment, secondary treatment, tertiary treatment, BOD (biochemical oxygen demand), sludge, oxygen-sag curve, non-point source pollution, point source pollution, combined sewer system, eutrophication, infiltration, runoff.

COND From memory.

PL At least 11 of the 12 terms should be correctly defined.

26
ACT List two water supply sources and describe the degree of purity necessary for six major uses of water.

COND From memory.

PL List should include groundwater and surface waters. Description should state the necessary treatment of the water in order for it to be used for irrigation, navigation, pollution control, power generation, food-processing, municipal water supply, recreation, and flood control.

27
ACT Diagram a typical sequence of unit operations at a municipal water treatment plant and describe what each step accomplishes.

COND From memory.

PL Description should include name and type of process unit, classes of materials removed and/or treated by the process unit, and a nontechnical functional description of the process unit.

28
ACT Explain why different materials should be removed from wastewater.

COND Given the names of materials in wastewater.

PL Explanation should include the effects upon the environment and upon treatment processes if the materials are not removed.

29
ACT List wastewater sources, their general characteristics, and their impact on receiving waters.

COND From memory.

PL List should include the major parameters and the effects on receiving waters.

30
ACT Draw a typical flow diagram for wastewater treatment.

COND Given a description of the wastewater characteristics.

PL Diagram should include:
1. All major unit processes. The following should be included where applicable:
   a. primary treatment (three types)
   b. secondary treatment (trickling filter, three types of activated sludge, lagoons)
   c. tertiary treatment (six types).
2. All flow directions, additions, and withdrawals.

31
ACT Describe the typical sequence of a wastewater treatment process and the unit components associated with each.

COND From memory.

PL Description should include name and type of process unit, classes of materials removed and/or treated by the process unit, and a nontechnical functional description of the process unit.

32
ACT Describe the physical, chemical, and biological principles involved in the functioning of various unit processes, their relative importance, and the characteristic changes in the wastewater that are brought about by each.

COND Given names of unit processes.

PL Description should include the various principles used in unit processes to treat wastewater, the relative importance of the unit process, and the changes in the wastewater characteristics which occur.

33
ACT Define the following terms: pyrolysis, sanitary landfill, compost, solid waste, recycling, secondary materials industry, biodegradable, leachate.

COND From memory.

PL At least 6 of the 8 terms should be correctly defined.

34
ACT List the sources of solid waste and their approximate composition.

COND From memory.

PL List should include five of the following sources of solid waste and their major components: residential, commercial, municipal, industrial, agricultural, mining and refining, and sludge.

35
ACT Discuss in essay form the related environmental considerations involved in the use of three conventional and two innovative types of solid waste disposal techniques.

COND From memory.

PL Discussion should include the aspects of solid waste disposal which are related to air and water pollution.

36
ACT Discuss the various levels of environmental quality that are attainable and the socio-economic and ecological trade-offs involved in formulating environmental policy.

COND Given selected reference materials.

PL Discussion should include the costs and benefits which are involved in developing guidelines for environmental protection.

37
ACT Describe various approaches which can be used in solving environmental problems and give examples from the different major areas of environmental pollution.

COND Given selected reference materials.

PL Description should include general approaches to control of environmental pollutants such as dilution, process modification or replacement, and isolation, and how they are used in water, air, solid waste, and radiation management.

38
ACT Write a research paper detailing the multidisciplinary aspects of one small area of environmental concern.

COND Given access to textbooks, journals, and interviews with environmental scientists, and planners.

PL Paper should explore in depth one small aspect of the total environmental situation. It should reflect the student's ability to deal with the complex nature of environmental problems and discuss various alternative approaches to use in dealing with the particular environmental problem.

39
ACT Describe by use of natural cycles how man's disposal practices have had a detrimental effect on these cycles, man, and the environment.

COND Given selected reference materials.

PL Description should include at least three of the natural cycles (e.g., hydrologic, carbon, nitrogen, sulfur, phosphorus, oxygen) and the effect the interruption of these cycles by manmade pollutants has on the environment and man's quality of life.

40
ACT Explain in general terms the purpose of various regulations and discuss their role in helping to maintain the quality of the environment and the health of mankind.

COND Given six of the following governmental health and environmental regulations:

Safe Drinking Water Act
Clean Air Act and Amendments
Occupational Safety and Health Act
National Environmental Policy Act
Solid Waste Disposal Act
Federal Food, Drug, and Cosmetic Act
Toxic Substances Control Act
Resources Conservation and Recovery Act
Clean Water Act

PL Explanation should include the purpose of each regulation and state its function in helping to maintain the quality of the environment.

41
ACT Describe monitoring and surveillance methods used for air and water pollutants and radiation in the work environment, atmosphere, rivers, and lakes.

COND Given a list of air and water pollutants and types of radioactive particles.

PL Description should include various instruments used in monitoring, different types of sampling methods, and federal and state programs involved with environmental monitoring and surveillance.

42
ACT Describe the detrimental effects which industrial, technological, domestic, and natural processes have on the environment.

COND Given the names of sources of pollution and of pollutants affecting air, water, and land use.

PL Description should include the kinds of waste from each source and the effects of each pollutant upon man and his environment.

43
ACT Discuss man's dependence on water and air and why water and air are essential to living things.

COND Given selected reference materials.

PL Discussion should include the role of air and water in various physical, chemical, and biological processes (e.g., solution, oxidation, metabolism, heat transfer, photosynthesis, assimilative capacity, power production, transportation).

Fluid Mechanics

PURPOSE

The purpose of this course is to teach the learner the fundamentals of fluid properties, the principles of fluid behavior, and the application of these principles to practical situations. Information about the flow of water and wastewater in pipes and in open channels will also be given.

PREREQUISITES

Before beginning this course the learner should have mastered the instructional objectives for Applied Calculus (Math III), Physics II, and Dynamics (Mechanics III).

COURSE OUTLINE

The topics covered in this course are listed below. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Properties of Fluids	1-4
Fluid Statics	5-13
Fluid Flow Concepts & Equations	14-25
Closed-Pipe Flow	26-32
Open-Channel Flow	33-42
Flow Measurement	43

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the student in learning this subject matter, to help the instructor in gathering lecture materials, and to furnish more in-depth information on a particular topic.

Brater, E. F. and King, H. W. *Handbook for the Solution of Hydrostatics and Fluid Flow Problems.* New York: McGraw-Hill, 1976.

Daugherty, R. and Franzini, J. B. *Fluid Mechanics with Engineering Applications.* New York: McGraw-Hill, 1977.

Simon, A. L. *Practical Hydraulics.* New York: John Wiley and Sons, 1976.

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT Define a fluid and describe how it differs from a solid and a gas.

COND From memory.

PL Description should include differences in closeness of molecules, attractive forces between molecules, magnitude of stress, and compressibility.

2
ACT Define the following terms used to describe properties of fluids: density, specific weight, viscosity, surface tension and capillarity, specific volume, specific gravity, compressibility, vapor pressure, cavitation. Definitions are to include the accepted units [English and Système Internationale (SI) Units] and the formulas for the various properties.

COND From memory.

PL All the terms should be correctly defined.

3
ACT Describe Newton's law of viscosity and show how it is used to classify fluids. (Examples of fluids in each classification should be given.)

COND From memory.

PL Description should include equation

$$\tau = \mu \frac{du}{dy}$$

and a sketch of a rheological diagram showing the relationship between the rate of deformation and shear stress for various fluids.

4
ACT Derive equations for calculating the pressure within a droplet of liquid and the capillary rise in a circular glass tube.

COND From memory.

PL The following equations should be given:

$$p = \frac{2\sigma}{r} \quad \text{and} \quad p = \frac{\sigma}{r}$$

(hemispherical) (cylinderical)

for pressure within a droplet of liquid.

$$h = \frac{4\sigma}{\gamma d}$$

for capillary rise in a circular glass tube.

5
ACT List several ways of expressing pressure in a static fluid.

COND From memory.

PL List should include the following: feet or meters of water, pounds per square inch or newtons per square meter, absolute pressure, gage pressure.

6
ACT Explain Pascal's law.

COND From memory.

PL Explanation should state that two points at the same elevation in the same continuous mass of fluid at rest have the same pressure.

7
ACT Derive an equation for pressure variation in a static incompressible fluid.

COND From memory.

PL The following equation should be derived:

$$p = \gamma h$$

8
ACT Derive an equation for pressure variation in a static compressible fluid for isothermal conditions.

COND From memory.

PL The following equations should be derived:

$$dp = -\gamma dh \quad \text{and}$$

$$h - h_o = \frac{p_o}{\gamma_o} \ell n \frac{p_o}{p}$$

9
ACT List four different instruments used for measuring fluid pressure.

COND From memory.

PL List should include barometer, bourdon gage, piezometer, and simple and differential manometers.

10
ACT Calculate the magnitude and point of application (center of pressure) of forces on the plane area submerged in a fluid.

COND Given the shape and dimensions of a submerged body and its distance below the surface of a fluid.

PL Calculations should be done using the following equation:

$$F = \gamma A\bar{h} \text{ and } y_{cp} = \frac{I_c}{A\bar{y}} + \bar{y}$$

11
ACT Calculate the magnitude and point of application (center of pressure) of forces on curved surfaces submerged in a fluid.

COND Given the shape and dimensions of a submerged body and its distance below the surface of a fluid.

PL Calculations should include the horizontal and vertical components of the forces, their points of application (center of pressure), and the resultant force.

12
ACT Define buoyant force, center of buoyancy, and metacenter.

COND From memory.

PL All the terms should be correctly defined.

13
ACT Discuss the stability of floating and submerged bodies and derive an equation to calculate the metacentric height of a floating body.

COND From memory.

PL The following equation should be derived:

$$\text{distance between center of buoyancy and the metacenter} = BM = \frac{I}{V}$$

14
ACT Describe the flow characteristics of the following types of flow: laminar, turbulent, steady, unsteady, uniform, nonuniform, rotational, irrotational.

COND From memory.

PL Descriptions should distinguish clearly the various types of flow.

15
ACT Derive the continuity equation and explain each term in the equation.

COND From memory.

PL The following equation should be derived:

$$Q = A_1 V_1 = A_2 V_2$$

16
ACT Write the equations for the kinetic energy, potential energy, and pressure energy of a particle of flowing fluid and give the units in which each of these is expressed.

COND From memory.

PL The following units and equations should be written:

equation	units
kinetic energy = $\frac{V^2}{2g}$	ft. lb/lb
potential energy = Z	ft. lb/lb
pressure energy = $\frac{p}{\gamma}$	ft. lb/lb

17
ACT Write and explain the Bernoulli equation for fluid flow.

COND From memory.

PL The following equation should be given:

$$\frac{p_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + h_L$$

Each term should be explained as a type of head or energy.

18
ACT Calculate (a) the total force due to a fluid acting on each side of a tank and (b) how many gallons of water are spilled when a tank is filled with water and accelerated horizontally.

COND Given tank dimensions and acceleration.

PL Calculations should be done using the following relative equilibrium equation for horizontal motion:

$$\tan \theta = \frac{a_x}{g}$$

19
ACT Calculate the force acting on the side of a tank when a tank is filled with water and is accelerated (a) vertically upward and (b) vertically downward.

COND Given tank dimensions and acceleration.

PL Calculations should be done using the following relative equilibrium equation:

$$p = \gamma h \left(1 \pm \frac{a_y}{g}\right)$$

20
ACT Calculate the quantity of water that will be spilled and the pressure at the center of the bottom of the tank when an open cylindrical tank filled with water is rotated about its central axis at a constant speed.

COND Given tank dimensions and angular speed.

PL Calculations should be done using the vortex motion equation for rotation:

$$y = \frac{\omega^2 x^2}{2g}$$

21
ACT Derive an equation for radial flow, that is, flow than can be produced by constraining a stream of fluid to flow between two parallel circular plates with openings at the center and the periphery.

COND From memory.

PL The following equation should be derived:

$$r_1 V_1 = r_2 V_2 = r_3 V_3 = \text{constant}, \; V \propto \frac{1}{r}$$

22
ACT Discuss power considerations as they affect fluid flow and give an equation to explain the effects.

COND From memory.

PL Discussion should include the development of an expression for power:

$$HP = \frac{\gamma Q E_p}{550}$$

and the modification of the Bernoulli equation by including the pump energy term:

$$\frac{p_1}{\gamma} + \frac{v_1^2}{2g} + z_1 + E_p = \frac{p_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + h_L$$

23
ACT Define the terms *hydraulic grade line* and *energy grade line* and give illustrations of each.

COND From memory.

PL Illustrations should include a diagram showing the hydraulic grade line and the energy grade line in a pipe system which includes a pump.

24
ACT Explain dynamic force (including examples of dynamic forces which result from fluid flow) and develop the linear-momentum equation from Newton's law.

COND From memory.

PL Explanation should include how dynamic force results from a change in the direction or magnitude of velocity of a flowing fluid, the equations:

$$\Sigma F_x = \rho Q (V_2 - V_1)_x \quad \text{and}$$

$$\Sigma F_y = \rho Q (V_2 - V_1)_y$$

and give examples of stationary and moving vanes and reducing pipe bends.

25
ACT Determine the torque in the pump shaft, the horsepower input, and the energy added to the flow by the impeller.

COND Given discharge leaving the impeller, its dimensions, velocity components, and pump speed.

PL Calculations should be done using the angular momentum or moment of momentum equation:

$$T = \rho Q [(rv_t)_2 - (rv_t)_1]$$

26
ACT Define Reynolds number and use it to identify when the flow in the pipe is laminar and when it is turbulent.

COND Given a pipe of known diameter and length which has water flowing through it at varying velocities.

PL Identification should be done by calculating the Reynolds number for the various velocities and then classifying flow as either laminar or turbulent according to the calculated Reynolds number.

27
ACT Calculate the head loss in a pipe.

COND Given the discharge, a pipe of known material, length, and diameter, and a Moody diagram.

PL Calculations should involve the use of the Moody diagram to estimate the friction factor and the Darcy-Weisbach equation.

28
ACT Calculate the discharge in the pipe.

COND Given head loss, a pipe of known material, length, and diameter, and a Moody diagram.

PL Calculations should involve the use of the Moody diagram and the Darcy-Weisbach equation.

29
ACT Calculate the diameter of a pipe.

COND Given the head loss, discharge, a pipe of known length and material, and a Moody diagram.

PL Calculations should use the Moody diagram and the Darcy-Weisbach equation.

30
ACT Calculate the total head loss due to fluid flow through pipes connected in series.

COND Given pipes of different known diameters and pipe material connected in series which have a known quantity of water flowing through the system; and given the Hazen-Williams equation or the Darcy-Weisbach equation.

PL Calculations should be done using the total head loss in the system as being equal to the sum of the head losses in each section.

31
ACT Calculate the discharge in each pipe line (branching) in a parallel pipe system.

COND Given the total head loss and a pipe of known length, diameter, and material.

PL Calculations should involve the use of the Darcy-Weisbach or Hazen-Williams equations and the following equations:

$$Q_i = Q_1 + Q_2 = Q_o$$

$$h_{f_1} = h_{f_2} = h_f$$

32
ACT Calculate the minor head loss due to flow through the following hydraulic fixtures: different types of entrances, sudden or gradual expansion, sudden or gradual contraction, valves (gate, globe, rotary, and check valves), elbows, bends, different types of exits.

COND Given the dimensions of the hydraulic fixtures, the discharge, loss coefficients, and reference materials.

PL Calculations should be done using the appropriate equations, charts, and tables.

33
ACT Derive both the Chezy and the Manning equations for steady, uniform flow in an open channel.

COND From memory.

PL The following equations should be derived:

first $\tau = \gamma RS$ and then $V = C\sqrt{RS}$ (Chezy)

and $V = \frac{1.486}{n} R^{2/3} S^{1/2}$ (Manning).

34
ACT Calculate the discharge in an open channel.

COND Given an open channel section of known shape, dimensions, and bed slope, and the Manning *n* values.

PL Calculations should be done using the Manning equation for velocity and then Q = AV.

35
ACT Calculate the normal depth in an open channel.

COND Given an open channel section of known shape, dimensions, bed slope, and discharge, and the Manning *n* values.

PL Calculations should be done using the Manning equation for velocity and calculating normal depth by repeated trial and error.

36
ACT Calculate the discharge in a floodway.

COND Given the channel cross section and river stage, the Manning *n* values, and the slope of the energy grade line.

PL Calculations should be done by determining the discharge for each portion separately using dashed vertical lines to separate the various sections (not a solid boundary) and then adding the discharges to determine the total capacity of the system using the following equations:

$$Q_1 = K_1\sqrt{S},\ Q_2 = K_2\sqrt{S},\ Q_3 = K_3\sqrt{S} \text{ and}$$

$$Q = (K_1 + K_2 + \ldots . K_n)\sqrt{S} \text{ where}$$

$$K = \frac{1.486}{n} AR^{2/3} = \text{conveyance factor.}$$

37
ACT Calculate the diameter of a sewer pipe when it is flowing partially full.

COND Given a sewer pipe of known bed slope and discharge, the Manning *n* values, the ratio of depth of flow to the diameter of the pipe, and the trigonometric equations for partial flows.

PL Calculations should be done using trigonometric functions or mathematical tables to find the angle subtended by surface liquid level at the center, solving for hydraulic radius in terms of diameter, and finally determining the diameter using the Manning equation.

38
ACT Derive equations for best hydraulic-channel cross sections.

COND From memory.

PL The following equations should be derived for the various shapes of cross sections:

rectangular: $b = 2y,\ R = \frac{y}{2}$

trapezoidal: $p = 2\sqrt{3}\,y,\ A = \sqrt{3}\,y^2,$

$R = \frac{y}{2},\ z = \frac{1}{\sqrt{3}},\ b = \frac{2}{\sqrt{3}}y,$

triangular: $z = 1$

39
ACT Draw diagrams to explain the following terms pertaining to open channel flow: specific energy, critical depth, critical velocity, Froude number, supercritical flow, subcritical flow.

COND From memory.

PL Explanation should include: (a) depth vs. specific energy diagram [discharge (Q) being constant] (b) depth vs. discharge diagram [energy (E) being constant].

40
ACT Derive an hydraulic jump equation to determine the conjugate depths for a given discharge and an equation for energy loss due to the hydraulic jump.

COND From memory.

PL The following equations should be derived:

$$y_2 = \frac{y_1}{2}\left[-1 + \sqrt{1 + \frac{8q^2}{gy_1^3}}\right] \quad \text{and}$$

$$\text{energy loss} = E_J = \frac{(y_2 - y_1)^3}{4y_1 y_2}$$

41
ACT Calculate the length of the backwater curve in an open channel.

COND Given an open channel of known cross section, bed slope, and discharge, the Manning *n* values, and the height of the dam.

PL Calculations should be done using the direct-step method equations:

$$s_o \Delta x + y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} + s_f \Delta x, \text{ and}$$

$$\text{then } s_f = \frac{n^2 V^2}{2.22R^{4/3}}$$

to find the length of the backwater curve using a suitable number of steps.

42
ACT Calculate the surface water elevation at a given section in a stream.

COND Given the starting water elevation, the channel cross sections, and the Manning *n* values.

PL Calculations should be done using the standard-step method equations:

$$z_1 + \frac{V_1^2}{2g} = z_2 + \frac{V_2^2}{2g} + h_f \quad \text{and}$$

$$h_f = \frac{s_{f_1} + s_{f_2}}{2} \Delta x$$

to find z_2 by trial and error.

43
ACT Explain and demonstrate the following devices used to measure flow: current meter, pitot tube, broad-crested weir, different types of notches, Parshall flume, Venturi meter, orifice plate, flow nozzle.

COND Given reference materials and access to the above instruments.

PL Explanation should include the equations used with each piece of equipment.

Water Quality Management

PURPOSE

The purpose of this course is to provide the learner with an introduction to the many aspects of water quality management. The course will include the historical development of water quality management with emphasis on current legislation; use of computer modeling for water quality management studies and application of the results to decision-making; public participation requirements; wastewater treatment alternatives and evaluation of cost-effectiveness; and legal, financial, enforcement, and regulatory considerations.

PREREQUISITES

Before beginning this course the learner should have mastered the instructional objectives for Environmental Sanitation. This course is a prerequisite for the Water Quality Management Internship.

COURSE OUTLINE

The topics covered in this course are listed below. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Water Pollution Control Legislation	1,2
Water Quality Planning	
1. Clean Water Act	3-7
2. National Environmental Policy Act	8
Public Participation	9-11
Safe Drinking Water	12
Agency Involvement	13-16
Effluent Standards	17,18
Treatment Alternatives	19-21
Funding	22-27
Simulation	28

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the learner in understanding this subject matter, to help the instructor in gathering lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

Pavoni, Joseph L. (ed.). *Handbook of Water Quality Management Planning.* New York: Van Nostrand Reinhold, 1977.

Other Instructional Resources

Water Pollution Control Legislation	IRIS 828, 1107, 1289, 1295, 1661, 1824, 1835, 2020, 2028, 2618
Water Quality Planning	
1. Clean Water Act	IRIS 165, 828, 1002, 1092, 1657, 1659, 1661, 1686, 1687, 1957, 2028, 2163, 2713, 2768, 2898 VC-77, VC-78
2. National Environmental Policy Act	IRIS 1657, 1686, 1687, 2395, 2615, 2617, 2623, 2898
Public Participation	IRIS 177, 828, 1092, 1280, 1281, 1282, 1709, 1824, 1943, 2215, 2254, 2357, 2933 MP-7
Safe Drinking Water	IRIS 492, 1081, 1835, 2177, 2918 MP-63, VC-72, VC-73
Agency Involvement	IRIS 828, 1000, 1092, 1281, 2067, 2163, 2618, 2933
Effluent Standards	IRIS 1681, 1685, 1689, 1696, 2559
Treatment Alternatives	IRIS 828, 1163, 1404, 1581, 1657, 1659, 1661, 1664, 1682, 1688, 1690, 1908, 1909, 1915, 1933, 1946, 1964, 2028, 2057, 2059, 2062, 2167, 2210, 2254, 2412, 2555, 2874, 2876, 2893
Funding	IRIS 177, 828, 1092, 1289, 1393, 1396, 1664, 1697, 1820, 2184, 2555, 2875, 2923
Simulation	IRIS 187, 1092, 1657, 1659, 2254, 2615, 2617, 2623, 2713

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT List in chronological order at least six major pieces of legislation which reflect the historical development of water pollution control and give the major contributions made by each.

COND From memory.

PL List should include six of the following:
- The Rivers and Harbors Act of 1899
- The Oil Pollution Act of 1924
- The Water Pollution Control Act of 1948
- The Water Pollution Control Act Amendments of 1956
- The Water Pollution Control Act Amendments of 1961
- The Water Quality Act of 1965
- The Clean Waters Restoration Act of 1966
- Safe Drinking Water Act of 1974
- The Clean Water Act of 1977

2
ACT List the most important features of the Clean Water Act of 1977 (PL 95-217) and explain their implications with respect to environmental control.

COND Given a copy of PL 95-217.

PL List should include the six objectives of the Act; the names of the federal and state agencies that will cooperate in water pollution control; types of research investigations, training and information transfer the Act will instigate; features of the construction grant program, development of a comprehensive and continuing planning process for water quality management; and the establishment by the states of a permit program for pollutant discharge.

3
ACT Describe in general terms the scope and purpose of the various levels of planning as established by Sections 201, 208, 209 and 303 of the Clean Water Act (PL 95-217) and note their roles are interrelated to help achieve and maintain clean water.

COND Given a copy of PL 95-217.

PL Description should discuss the hierarchy of water quality management planning and show how the dependent nature of the distinct roles of various planning levels works to achieve greater efficiency.

4
ACT Discuss the major objectives of the Basin Plan (Section 303) and the types of data and information that must be collected in order to prepare the plan.

COND Given a copy of PL 95-217 and class lecture notes.

PL Discussion should mention that the plan must include an assessment of the nature and extent of pollution in the river basin, a strategy to regulate discharges in various segments by issuance of permits, and the establishment of priorities for the construction and modification of treatment plants in the basin area.

5
ACT Describe in detail the Areawide Waste Treatment Planning process (208 planning), including the intent and scope of 208 planning and its present status.

COND Given a copy of PL 95-217 and class lecture notes.

PL Description should include specific types of information which must be included in a 208 plan, sources of information needed to develop the plan, and various activities necessary to formulate a 208 plan. A PERT chart of the process should be developed.

6
ACT List at least seven major activities necessary in the development of a 201 Facility Plan.

COND Given a copy of PL 95-217 and class lecture notes.

PL List should include seven of the following activities:

Establish water quality management goals
Prepare a detailed inventory of existing waste treatment systems
Prepare an environmental inventory
Estimate future waste loads and flows
Develop technical alternatives
Analyze cost-effectiveness
Establish a public participation program
Prepare environmental impact statement
Develop implementation arrangements
Select a 201 plan from the alternatives

7
ACT Discuss the relationship between land use and the quality and quantity of water resources and show how land use considerations fit into the 201 and 208 planning processes.

COND Given a copy of PL 95-217 and class lecture notes.

PL Discussion should include the interaction between different land uses and water quality and quantity, as well as how federal legislation concerning water quality management planning (PL 95-217) affects planning for land use.

8
ACT Discuss the features of the National Environmental Policy Act (NEPA) which have significance for water quality management and planning.

COND Given a copy of NEPA and class lecture notes.

PL Discussion should include but not be limited to NEPA requirements that socio-economic and ecological considerations be given more weight in decisions that interfere with the environment and how NEPA attempts to restructure previous methods of decision-making. The requirement of environmental impact statements in planning water resources projects and the preparation of alternative plans should be stressed.

9
ACT Discuss the purpose and necessity of public participation in the water quality management planning process including the legal requirements as set forth by regulations issued by the Environmental Protection Agency (EPA).

COND From memory.

PL Discussion should include benefits that public participation can bring to decision-making in the planning process, as well as the specific types of activities required on the state level by the regulation.

10
ACT List 5 professional organizations involved in water quality control and describe briefly their role.

COND From memory.

PL List should include at least 5 of the following organizations:

American Chemical Society
American Institute of Chemical Engineers
American Public Health Association
American Public Works Association
American Society of Civil Engineers
American Society of Mechanical Engineers
American Water Works Association
Associated Boards of Certification
National Sanitation Foundation
Water Pollution Control Federation

11
ACT List 5 citizen-action organizations which interact with governmental agencies in effecting pollution control and describe briefly the function of each.

COND From memory.

PL List should contain at least 5 of the following organizations:

Audubon Society
Ducks Unlimited
Environmental Defense Fund
Friends of the Earth
Issac Walton League
League of Women Voters
National Resources Defense Council
National Wildlife Federation
Sierra Club
Wilderness Society

12
ACT List the basic components of the Safe Drinking Water Act of 1974 (PL 93-523) and subsequent amendments and explain their implications with respect to environmental protection.

COND Given a copy of PL 93-523 and class lecture notes.

PL List should include regulations concerning public water systems, regulations for protection of underground sources of drinking water, and the general provision for ensuring purity of water supply (e.g., treatment regulations, training, records, inspection).

13
ACT Identify the departments and agencies of the executive branch of the federal government concerned with environmental protection and explain briefly their role in environment-related matters.

COND Given a list of all the departments and agencies in the executive branch of the federal government.

PL Identification should include at least 12 departments and agencies.

14
ACT Identify the committees and organizations of the legislative branch of the federal government which are concerned with environmental protection and explain briefly their role in environment-related matters.

COND Given a list of all Congressional committees and organizations.

PL Identification should include at least 10 committees and organizations.

15
ACT List the state agencies and organizations concerned with environmental protection and describe briefly the function of each.

COND Given a directory of state agencies.

PL Description should mention the administrative, technical assistance, research, training, legal, and regulatory functions of state agencies involved in control of air, water, toxic substances, radiation, and solid waste pollution.

16
ACT List the local agencies (county and municipal) concerned with environmental protection and describe briefly the function of each.

COND Given a directory of local agencies.

PL Description should mention the administrative, technical assistance, research, training, legal, and regulatory functions of local agencies involved in control of air, water, toxic substances, radiation, and solid waste pollution.

17
ACT Discuss the various levels of effluent standards as set forth by PL 95-217 and the role of the National Pollutant Discharge Elimination System (NPDES).

COND Given copies of PL 95-217.

PL Discussion should include how the effluent levels are established.

18
ACT Identify and describe four of the economic factors involved with pollution control and the National Pollution Discharge Elimination System (NPDES).

COND From memory.

PL Description should include the following factors: cost of pollution control, impact on employment, impact on existing pollution control facilities, energy consumption of new pollution control facilities.

19
ACT Describe in general terms the advantages and disadvantages of the various wastewater treatment techniques.

COND Given a list of wastewater treatment techniques.

PL Description should include construction cost, operating and maintenance costs, efficiency of pollutant removal, flexibility of design, limitations, land requirement, and sensitivity to wastewater variations.

20
ACT List and discuss the various aspects of cost estimation of various wastewater treatment techniques and show how they are combined to produce cost estimates of entire wastewater treatment schemes.

COND Given reference materials and class lecture notes.

PL Discussion should include various aspects of cost estimation, such as sources, reliability, estimating procedures, types of estimates, indexing, economy of scale, and methods of comparing cost estimates for cost-effectiveness.

21
ACT Discuss the advantages and disadvantages of using models to simulate the relationships among sets of variables or natural processes to develop water quality management strategies.

COND From memory.

PL Discussion should note that models vary because of many factors, such as quality of input data, sophistication of mathematical relationships used to describe natural processes, water quality parameters chosen, computing techniques used, understanding of process being simulated, and degree of verification of the model. Use of a model should also be related to the level of detail of the problem and the type of decision to be made from the output.

22
ACT Identify some of the sources of funds available from federal, state, and local governments for water quality control projects.

COND From memory.

PL At least 5 funding sources should be named.

23
ACT Discuss the bond process as a source of funding for water quality control projects.

COND Given class lecture notes.

PL Description should include sources of bonds, interest and amortization requirements, and the process of issuing bonds.

24
ACT List and describe the steps involved in the grant process with respect to a planning (step 1) grant.

COND Given a copy of PL 95-217 and reference materials.

PL Description should include the mechanisms involved in obtaining the grant, as well as the criteria that must be met.

25
ACT List and describe the steps involved in applying for a design (step 2) grant.

COND Given a copy of PL 95-217 and reference materials.

PL Description should include the review procedures involved and the specific criteria to be met.

26
ACT List and describe the steps involved in applying for a construction (step 3) grant.

COND Given a copy of PL 95-217 and reference materials.

PL Description should include the mechanisms involved in obtaining the grant, as well as the criteria that must be met.

27
ACT List and describe the steps involved in applying for a research and/or demonstration grant.

COND Given a copy of PL 95-217 and class lecture notes.

PL Description should include details about the obligations of the grant recipient.

28
ACT Participate in a simulation (role-playing) game concerning environmental problems.

COND Given a group of interested people with various experience and education backgrounds and access to a simulation game such as APEX.

PL Student should have fun.

Water Quality Management Internship

PURPOSE

The purpose of this course is to give the learner an actual work experience related to water quality management. The experience should organize and put into perspective the several years of training that have preceded this assignment. The specific objectives of the internship will vary depending on the agency/firm in which the person is placed.

PREREQUISITES

Before beginning this course, the learner should have mastered the instructional objectives for Engineering Surveys, Environmental Sanitation, Water Quality Management and Water/Wastewater Chemistry and Microbiology.

COURSE OUTLINE

The assignments in the internship program will be made in one of three sub-areas. They are as follows:

Enforcement, Monitoring, and Surveillance
Planning
Implementation

A. Enforcement, Monitoring, and Surveillance

Purpose: The purpose of this internship is for the learner to become acquainted with the application of local, state, and federal regulations and laws to water quality control problems. Techniques and procedures for sampling surveys will be learned and the required analyses will be performed. In addition, the learner will develop procedures for evaluating performance and compliance with standards of wastewater treatment plants.

1
ACT Describe in essay form the procedure for interpreting and evaluating the appropriate local, state, or federal regulation applicable to a water quality control problem.

COND Given a specific water quality control problem, all available data, and reference materials.

PL Description should include:
a. how to determine the appropriate regulation(s)
b. how to select the appropriate data relating to the problem
c. interpretation of the regulation in relation to the data
d. control action dictated by the regulation.

2
ACT Describe in essay form the procedure for sampling surveys.

COND Given a specific water quality problem.

PL Description should include: a. the criteria for determining need for the survey, the samples to be taken, and the analyses to be made. b. sampling locations, frequency, and schedule. c. statistical data analysis and evaluation.

3
ACT Describe in essay form the procedures for evaluating treatment plant performance.

COND Given all available references.

PL Description should include:
a. reference materials (standards, regulations, and specifications)
b. samples to be taken (location, type, and frequency)
c. analyses to be performed
d. calculations to be performed
e. graphs and tables to be prepared
f. interpretations to be made
g. control actions to be made.

4
ACT Describe in essay form the procedures for evaluation of design plans.

COND Given a specific problem, all available data, and reference materials.

PL Description should include:
a. reference materials (standards, regulations, and specifications)
b. calculations
c. forms and charts to be completed
d. actions to be taken.

B. Planning

Purpose: For a given project the learner will assist agency/firm personnel in the following planning actions. At least one of these actions will be performed in detail.

1
ACT Identify wastewater management needs in terms of public health hazards and treatment requirements.

COND Given a specific problem, all available data, and reference materials.

PL Identification should include reference to existing stream uses and standards.

2
ACT Delineate planning areas and plan priorities.

COND Given a specific problem, all available data, and reference materials, and working with a planner.

PL Report should specify each subdivision watershed or political area and list at least two water quality priorities for each.

3
ACT Delineate municipal sewer service areas, populations, flow needs, and resources.

COND Given a specific problem, all available data, and reference materials.

PL A comprehensive map and tables for each area should be prepared.

4
ACT Identify wastewater management alternatives for both point and non-point sources including location, size, and timing of alternative implementation.

COND Given a specific problem, all available data, and reference materials, and working closely with an engineer.

PL List of alternatives should have considered land treatment, on-lot disposal, water conservation, and innovative technology.

5
ACT Develop cost estimates for wastewater management alternatives.

COND Given a specific problem, all available data, and reference materials, and working closely with an engineer.

PL Estimates are to be based on references such as EPA's publication entitled "A Guide to Selection of Cost-Effective Wastewater Treatment Systems."

6
ACT Select recommended wastewater management alternatives.

COND Given a specific problem, all available data, and reference materials.

PL Selection should demonstrate considerable thought and knowledge in support of the chosen alternative, as well as familiarity with applicable laws, regulations, and state/federal policy guidance.

7
ACT Prepare an environmental impact assessment for a water quality management project.

COND Given a specific problem, all available data, and reference materials, and working with persons from various disciplines including engineers, biologists, chemists, sociologists, planners, and economists.

PL Assessment should include description and evaluation of the existing facility, prediction for future demands, and a description of all feasible alternative plans. Assessment should also include both primary and secondary impacts to natural and socio-economic features and emphasize regulatory guidelines. Trade-offs for environmental concerns and feasible economics should be considered.

8
ACT Identify planning and implementing agencies.

COND Given a specific problem, all available data, and reference materials.

PL Identification should include all the federal, state, and local agencies that will be involved.

9
ACT Outline planning standards and evaluation mechanisms for a water quality management project.

COND Given a specific problem, all available data, and reference materials, and working closely with a planner.

PL Description should include the specific laws including regulations that are applicable, the specific types of information that must be included, and the method of evaluating the project results.

10
ACT Outline necessary public participation at all phases during the implementation of a water quality management project.

COND Given a specific problem, all available data, and reference materials.

PL Outline should show how the public participation will be used by the planners in making decisions for succeeding phases.

C. Implementation

Purpose: The learner will assist existing personnel in the implementation of a water quality management plan.

1
ACT Determine whether or not schedules are being met. If the schedules are not being met, then suggestions for methods of improving action should be given.

COND Given a specific water quality control problem, all available data, and reference materials.

PL A table with target and actual task completion dates should be prepared.

2
ACT Identify revisions that should be made to the original plan because of changing technology and new conditions.

COND Given a specific water quality control problem, all available data, and reference materials.

PL At least five suggested revisions to the plan should be listed.

3
ACT Analyze environmental assessments to determine if a plan has been effective.

COND Given a specific water quality control problem, all available data, and reference materials, and working closely with a planner and other experts (e.g., aquatic biologist).

PL Analysis should include figures with water quality results for the important stream criteria for at least five years before project changes were made to the present, as well as other environmental considerations such as effects on non-point source flows and loads, secondary effects on the area (e.g., land use), and whether agency regulations or guidelines should, or have been, established as problems were discovered.

4
ACT Develop new methods of evaluating planning effectiveness.

COND Given a specific water quality control problem, all available data, and reference materials, and working closely with a planner.

PL A review of the literature on planning and suggestions for at least two new ways of evaluating the project results should be made.

5
ACT Outline an evaluation of public opinion with respect to planning satisfaction.

COND Given a specific water quality control problem, all available data, and reference materials, and working closely with a sociologist.

PL Activity should include both interative and mail questionnaire.

Water Pollution Abatement

PURPOSE

The purpose of this course is to familiarize the learner with water pollution from both point and non-point sources, the impact of these pollutants on the receiving waters, and the theory of the fundamentals of unit processes used to treat wastewater.

PREREQUISITES

Before beginning this course the learner should have mastered the instructional objectives for Water/Wastewater Chemistry and Microbiology, Environmental Sanitation, and Engineering Economy. This course is a prerequisite for Operation and Control of Treatment Plants.

COURSE OUTLINE

The topics covered in this course are listed below. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Water Quality	1-3
Characteristics of Wastewaters	4,5
Water Requirements and Wastewater Volumes	6,7
Water and Wastewater Treatment Schemes	8
Physical/Chemical Treatment Processes	9-11
Biological Treatment Processes	12-18, 32
Disinfection Processes	19-21
Sludge Processing and Disposal	22-26
Advanced Wastewater Treatment Processes	27-31
Water Reuse	33
Cost	34

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the learner in understanding this subject matter, to help the instructor in gathering lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

IRIS 886, 1037, 2381, 2896

Metcalf and Eddy, Boston. *Wastewater Engineering.* 2nd ed. revised by George Tchobanoglous. New York: McGraw-Hill, 1979.

Steel, E. W. and McGhee, Terence J. *Water Supply and Sewerage.* 5th ed. New York: McGraw-Hill, 1979.

Other Instructional Resources

Water Quality	IRIS 164, 184, 481, 486, 690, 691, 733, 743, 845, 1424, 1761, 1815, 1823, 2404
Characteristics of Wastewaters	IRIS 3, 191, 571, 1657, 1760, 1761, 1823, 2934
Water Requirements and Wastewater Volumes	IRIS 589, 905, 1005, 1031, 2547, 2882 VC-22
Water and Wastewater Treatment Schemes	IRIS 8, 141, 459, 463, 1045, 1250, 1454, 1455, 1760, 1807, 2381, 2934 MP-14
Physical/Chemical Treatment Processes	IRIS 141, 459, 535, 692, 836, 1040, 1260, 1657, 1761, 2934 MP-4
Biological Treatment Processes	IRIS 141, 459, 535, 571, 691, 692, 1242, 1260, 1657, 1761, 1807, 2167, 2934 MP-13
Disinfection Processes	IRIS 3, 141 472, 535, 556, 571, 692, 1040, 1260, 1761, 1787, 1800
Sludge Processing and Disposal	IRIS 9, 126, 128, 141, 459, 535, 549, 560, 692, 1040, 1043, 1260, 1263, 1426, 1661, 1760, 2190, 2211, 2910
Advanced Wastewater Treatment Processes	IRIS 440, 475, 795, 838, 1001, 1040, 1146, 1242, 1260, 1293, 1401, 1807 MP-31
Water Reuse	IRIS 150, 459, 795, 1291, 1416, 1661, 1815, 1926, 1957, 2216, 2217, 2882
Cost	IRIS 459, 1260, 1807, 1815, 1957, 2057

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT Describe the effects of chemical, physical, and biological pollution on receiving waters.

COND Given appropriate reference materials and class lecture notes.

PL Description should include eutrophication, biological oxygen demand, unsightly conditions, changes in aquatic life, limitation of recreational use, unpleasant odors and taste, health hazards, and interference with water reuse.

2
ACT Distinguish between water pollution criteria and standards and give examples of each.

COND Given the state or federal designated uses and criteria.

PL Description should list the major uses for which water is designated and include at least the following criteria: dissolved oxygen, pH, temperature, bacteria, phosphate, and ammonia nitrogen.

3
ACT Discuss the kinetics of aerobic decomposition of organic wastes in a stream.

COND Given stream with imposed waste load and pertinent reaeration and oxygen uptake equations.

PL Discussion should give particular attention to the dissolved oxygen concentration pattern in the stream, as well as cite other possible processes occurring in the stream which may affect reaeration and oxygen uptake.

4
ACT Discuss and compare sources and effects of point and non-point sources of pollution.

COND From memory.

PL Discussion should include urban and rural runnoff, on-lot disposal, air pollution fallout, and domestic and industrial wastes.

5
ACT Describe the characteristics of domestic and industrial wastewaters.

COND From memory.

PL Description should include composition, strength, and sources of both types of wastewater.

6
ACT List the types and sources of information necessary to determine present and future wastewater flows and water demands.

COND Given appropriate reference materials.

PL Student should list various sources of population, land use, economic data, and usage factors for residential, commercial, and industrial areas.

7
ACT Describe the mathematical and graphical methods of estimating future population densities, water demand, and wastewater production.

COND Given population data and growth information and water use data and patterns.

PL Description should include short-term and long-term methods of forecasting population growth, as well as factors to be considered in predicting water consumption rates and wastewater flow.

8
ACT Draw a typical flow diagram for water and wastewater treatment.

COND From memory.

PL Diagram should include the general categories important to the treatment of surface waters for potable use and of domestic wastewater by normal secondary treatment.

9
ACT Describe preliminary treatment processes for wastewater.

COND Given a flow diagram of a wastewater treatment plant.

PL Description should include a detailed account of the following preliminary treatment processes: coarse and medium screening, comminution, flow measuring, pumping, grit removal, preaeration, flotation, flocculation, and chemical treatment.

10
ACT Describe physical-treatment processes for water and wastewater.

COND Given class lecture notes.

PL Description should include screening devices, mixing and agitation, sedimentation, and filtration.

11
ACT Compare and contrast the various types of sedimentation used in water and wastewater treatment.

COND Given descriptions of several types of water and wastewater and class lecture notes.

PL Discussion should include the theoretical aspects of various types of sedimentation including Stokes, flocculent, zone, compression, and high-rate settling (tube and plate), as well as indicate how this knowledge can be used in the design of treatment plants.

12
ACT Describe the theory of biological decomposition of wastewater.

COND From memory.

PL Description should include types of microorganisms involved, differences between aerobic and anaerobic metabolism, nutritional and oxygen requirements for microbial growth, environmental factors affecting growth, and kinetics of microbial populations in mixed cultures.

13
ACT Identify the various activated-sludge processes.

COND Given flow diagrams for different activated-sludge processes.

PL Students should identify the following activated-sludge processes: conventional, step-aeration, contact stabilization without primary sedimentation, high-rate (complete mixing), extended aeration without primary sedimentation, and high-purity oxygen.

14
ACT Describe the methods of aeration of activated-sludge.

COND Given appropriate reference material and class lecture notes.

PL Description should include both mechanical and diffusion aeration systems.

15
ACT List the major components of a trickling filter and describe their role in biological treatment of municipal wastewater.

COND Given a trickling filter diagram and class lecture notes.

PL Description should include the role of the filter medium, under-drainage system, and rotary distributor in the biological treatment of primary effluent.

16
ACT Describe the biological processes which occur in lagoons.

COND Given appropriate reference materials and class lecture notes.

PL Description should include metabolism of organic waste by primary and secondary feeders, anaerobic digestion of settled solids, and algal photosynthesis.

17
ACT Identify the various types of lagoons.

COND Given diagrams of lagoons and wastewater characteristics.

PL Student should be familiar with anaerobic lagoons, facultative lagoons, and aerobic lagoons (or stabilization ponds).

18
ACT Discuss land disposal as a potential technique for treating wastewater.

COND Given appropriate reference materials.

PL Discussion should include possible methods of applying wastewater to land, advantages and disadvantages of each method, and environmental concerns which should be considered.

19
ACT Discuss the potential methods and mechanisms of disinfection/sterilization of wastewater effluents and drinking water.

COND From memory.

PL Discussion should include how pathogenic bacteria are inactivated and/or removed from the water, as well as factors which affect the rate of microbial inactivation. Discussion should also include various methods such as ozone, ultraviolet radiation, and chlorination.

20
ACT Describe the chemical reactions involved in the chlorination process.

COND Given equations for 1) hydrolysis of chlorine gas, 2) dissociation of hypochlorous acid, and 3) residual curve for breakpoint chlorination.

PL Description should relate the chemical reactions to the chlorine-residual curve and mention how pH affects the reactions.

21
ACT Define the following terms: chlorine demand, free available residual chlorine, combined available residual chlorine, breakpoint chlorine dosage, chlorine requirement, prechlorination, post-chlorination.

COND From memory.

PL At least 6 of the 7 terms should be correctly defined.

22
ACT List the sources of sludge from a municipal wastewater treatment plant.

COND Given flow diagrams of several types of wastewater treatment plants.

PL List should include the unit processes which generate sludge in each type of wastewater treatment plant.

23
ACT Describe processes for thickening sludges.

COND Given sources and character of the original sludge.

PL Description should include gravity settling alone, gravity settling with elutriation, and dissolved air flotation.

24
ACT Describe methods of dewatering various samples of sludge.

COND Given the desired solids concentrations and type of sludge pretreatment.

PL Description should include the various types of conditioning prior to dewatering, as well as three mechanical dewatering methods.

25
ACT Describe methods of solids destruction.

COND Given class lecture notes.

PL Description should include anaerobic and aerobic digestion, wet oxidation, and incineration.

26
ACT Describe possible alternative locations for ultimate disposal or resource recovery of sludge solids.

COND Given treatment schemes of sludge solids and the location of the treatment plant.

PL Description should include discharge to the ocean, land application, burial in a sanitary landfill, incineration, and chemical recovery.

27
ACT Evaluate the needs for advanced wastewater treatment.

COND Given a) the designated uses of several streams, b) related criteria and standards for those streams, and c) quality of several treatment plants on those streams.

PL Evaluation should include the degree of advanced waste treatment needed at present and in the future, as well as the major factors to be considered in unit process selection.

28
ACT Describe methods of enhancing suspended solids removal in advanced wastewater treatment.

COND Given class lecture notes and selected reference materials.

PL Description should include filtration through granular beds, microscreening, and chemical coagulation and clarification.

29
ACT Describe non-biological methods of removing soluble carbonaceous materials from water.

COND Given class lecture notes and selected reference materials.

PL Description should include adsorption on activated carbon columns, powdered carbon treatment, and chemical oxidation.

30
ACT Describe advanced wastewater treatment processes used to remove inorganic nitrogen from wastewater.

COND Given class lecture notes and selected reference materials.

PL Description should include three of the following methods: biological nitrification-denitrification, ammonia reduction by air stripping, breakpoint chlorination, ion-exchange (NH_4^+), irrigation of cropland.

31
ACT Describe advanced wastewater treatment methods used to remove orthophosphates and polyphosphates.

COND Given class lecture notes and selected reference materials.

PL Description should include two of the following methods: chemical coagulation and clarification, biological-chemical precipitation and clarification, irrigation of cropland.

32
ACT Explain the function of on-site disposal systems for small rural and suburban wastewater treatment.

COND From memory.

PL Explanation should include the various on-site disposal systems available and why they are suitable for rural and suburban use.

33
ACT Propose possible opportunities for water reuse in municipalities as a means of meeting future water demands.

COND Given several case histories of water needs, water resources, and wastewater quality and quantity.

PL Proposal should include natural reuse of surface bodies of water, as well as direct reuse of treated wastewater effluents. Public health and economic considerations should be discussed.

34
ACT Compare the costs of the various wastewater treatment processes.

COND Given current costs for several alternative wastewater treatment unit processes.

PL Comparison should include efficiency, reliability, difficulty, operating costs vs. capital costs, and compatibility of the unit process in the overall treatment scheme.

Hydrology and Water Supply

PURPOSE

The purpose of this course is to teach the learner the basic hydrologic techniques and their applications to the control, regulation, and utilization of water. The learner will become familiar with the hydrologic cycle including precipitation, infiltration, evapotranspiration, runoff, and groundwater; rainfall-runoff processes; storm frequency and duration studies; hydrographs, flood frequency, flood routing, and urban drainage; and water distribution systems.

PREREQUISITES

The instructional objectives for Fluid Mechanics, Computer Programming (Math V), and Statistics (Math VI) should be mastered before beginning this course. This course is a prerequisite for Operation and Control of Treatment Plants.

COURSE OUTLINE

The following topics are covered in this course. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Hydrologic Cycle	1,2
Analysis of Precipitation Data	3-9
Runoff and Hydrographs	10-13
Statistical Analysis of Hydrologic Problems	14-16
Flood Routing	17
Groundwater	18-22
Water Distribution Systems	23-28
Pumps	29-34

INSTRUCTIONAL RESOURCES

The following resources are listed to aid students in learning this subject matter, to help instructors in gathering lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

IRIS 1037, 1751, 2388, 1894

Hjelmfelt, A. T., Jr., and Cassidy, J. J. *Hydrology for Engineers and Planners.* Ames, IA: Iowa State University Press, 1975.

Viessman, Warren, Jr., et al. *Introduction to Hydrology.* 2nd ed., New York: IEP-A, Dun-Donnelley Publisher, 1977.

Other Instructional Resources

Hydrologic Cycle	IRIS 159, 481, 750, 1769, 1830, 2545 VC-22
Analysis of Precipitation Data	IRIS 559, 1828, 1832, 2766
Runoff and Hydrographs	IRIS 559, 2759, 2766
Statistical Analysis of Hydrologic Problems	IRIS 559, 2066, 2759
Flood Routing	IRIS 33, 1108
Groundwater	IRIS 410, 464, 481, 485, 491, 497, 750, 751, 898, 905, 1269, 1769, 2548, 2766, 2780 MP-16, MP-62
Water Distribution Systems	IRIS 17, 18, 28, 460, 501, 740, 803, 905, 957, 1081, 1111, 1251, 1790, 2644, 2900
Pumps	IRIS 141, 491, 530, 688, 898, 905, 1111, 1269, 1937, 2354

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT Discuss the interrelationships between the various processes/phases of the hydrologic cycle.

COND Given a schematic diagram of the hydrologic cycle.

PL Discussion should include precipitation, evapotranspiration, runoff, infiltration, groundwater, and the intimate relationship of land and water.

2
ACT Discuss the various types of precipitation and the meteorological conditions which influence the amount of precipitation and how and when it occurs.

COND From memory.

PL Discussion should include the temperature, pressure, and volume interrelations affecting liquid and frozen types of precipitation, as well as fog drip and dew.

3
ACT Estimate values that are missing at one or more stations in a drainage basin.

COND Given precipitation data and reference materials.

PL Estimates should use the normal ratio method when finding a missing value representative of a long period of time and an isohyetal map to interpolate a value missing from a short period (e.g., a particular storm).

4
ACT Determine the consistency of a precipitation record.

COND Given precipitation data and reference materials.

PL Determination should include the use of double-mass curve analysis.

5
ACT Determine the intensity of rainfall.

COND Given precipitation data.

PL Determination should include calculation from raw precipitation data, as well as drawing mass rainfall curves.

6
ACT Estimate average precipitation over a given area.

COND Given precipitation data, class lecture notes, and reference materials.

PL Estimates should include both Thiessen polygon and isohyetal map methods.

7
ACT Analyze average precipitation of subbasins of a watershed.

COND Given precipitation data, class lecture notes, and reference materials.

PL Analysis should include the use of graphical methods (e.g., depth-area-duration curves) and analytical methods.

8
ACT Construct a synthetic storm at a given location.

COND Given reference materials and class lecture notes.

PL Construction should include both probable maximum precipitation (PMP) and 100-year storm hyetographs.

9
ACT Estimate streamflow at different stages.

COND Given measured stream discharges, stages at main and auxiliary stations, and reference materials.

PL Estimates should include the construction of both simple rating and slope-stage-discharge curves.

10
ACT Discuss the mechanics and various components of runoff.

COND From memory.

PL Discussion should include intercepted rainfall, infiltration, and depression storage and their relationship to runoff, as well as interflow, surface flow, and groundwater.

11
ACT Discuss in general hydrographs and unit hydrographs.

COND From memory.

PL Discussion should include the various components of a hydrograph and their uses.

12
ACT Estimate the amount of direct surface runoff for a particular rainfall.

COND Given stream flow and drainage area data.

PL Estimation should involve the construction of a unit hydrograph and synthetic flood hydrographs.

13
ACT Estimate the peak rate of runoff, total runoff volume, and runoff on paved surfaces.

COND Given class lecture notes and textbook.

PL Estimates should be obtained using the rational equation, the soil conservation service (SCS) method, and other quick methods.

14
ACT Use computer to statistically analyze hydrologic problems involving rainfall-runoff relationships.

COND Given rainfall-runoff data, topographic data, computer, and computer program.

PL Analysis should include curve fitting and multiple regression analysis.

15
ACT Discuss the theory of probability and its applications in rainfall intensity-duration-frequency curves, flood frequency, and drought frequency.

COND Given precipitation data, stream flow data, log-log paper, and reference materials.

PL Discussion should include Gumbel and Log Pearson methods.

16
ACT Estimate runoff from paved surfaces and design flows for storm sewers, culverts and highway drainage.

COND Given location of watershed, soil type, topographical map, class lecture notes, and reference materials.

PL Estimation should include rational formula and soil conservation service methods.

17
ACT Estimate the design flow for a spillway.

COND Given stream flow data, area-volume-elevation curves, and reference materials.

PL Estimation should use synthetic hydrograph and flood routing skills.

18
ACT Discuss the sources of groundwater and the water-bearing formations associated with groundwater.

COND From memory.

PL Discussion should include confined (artesian) and unconfined aquifers, as well as a diagram representing aquifer classification.

19
ACT Discuss the hydraulics of groundwater.

COND Given reference materials.

PL Discussion should include Darcy's law.

20
ACT Discuss the hydraulics of wells.

COND Given pumping data, log-log paper, and reference materials.

PL Discussion should include an analysis of the hydraulics of the well, use of the Theis method, and analysis of pumping test data.

21
ACT Determine safe yield of groundwater from an aquifer.

COND Given fluctuation of groundwater level, mean annual draft data, and reference materials.

PL Determination should include the use of Hill, Simpson, and Harding methods.

22
ACT Discuss the problem of saltwater intrusion in coastal aquifers.

COND From memory.

PL Discussion should include how and why saltwater entry may occur, as well as its prevention and control. The Ghyben-Herzberg relationship should also be included.

23
ACT Determine the required reservoir yield, capacity, and storage needed for a water supply.

COND Given hydrologic data, population data, and estimated consumption.

PL Determination of reservoir capacity and storage should include the Rippl method.

24
ACT Discuss in general terms the problems associated with water supply distribution.

COND From memory.

PL Discussion should include water quantity, use, and storage.

25
ACT Determine the diameters of the water supply mains and submains.

COND Given necessary elevations and distances at various points, water surface elevation in reservoir, and water consumption rate.

PL Determination should include nomograph of Hazen-Williams equation.

26
ACT Determine the discharges and head loss in various pipes due to the flow distribution in a pipe network system.

COND Given computer, computer program, and a network of pipes of known lengths, diameters, and roughness which have a known quantity of fluid entering and leaving them at one or more points.

PL Determination should include the use of the Hardy Cross method and the flow correction equation.

27
ACT Determine the rise in pressure at a valve due to a water hammer resulting from closure of a valve in a pipe line.

COND Given diameter, wall thickness, and length of steel pipe used to drain a reservoir, the difference in elevation between the water surface in the reservoir and a valve on the end of the pipe drain, and modulus of elasticity of pipe walls.

PL Determination should be done for an instantaneous closure, as well as a gradual closure.

28
ACT Discuss various devices used to reduce or eliminate water hammers.

COND From memory.

PL Discussion should include surge tanks and relief valves.

29
ACT Explain the difference between various types of pumps used in water systems and comment on the advantages and disadvantages of each.

COND From memory.

PL Explanation should include the differences between the pumps in the following pairs:
displacement and centrifugal
reciprocating and rotary
volute and turbine-type
single suction and double suction
single and multistage
open impeller and closed impeller
horizontal and vertical

30
ACT Calculate the head developed and the quantity of fluid delivered when two centrifugal pumps are connected in series, as well as in parallel.

COND Given two identical centrifugal pumps that each deliver a known quantity of fluid at a known head.

PL Calculations should use both parallel pipe flow theory and pipes in series theory.

31
ACT Calculate the specific speed of a centrifugal pump that delivers a given quantity of water against a known head at a known rotative speed.

COND Given all necessary data.

PL Calculations should involve the use of specific speed formulas.

32
ACT Determine the capacity of a pump that will be pumping against a known head.

COND Given a set of data including flow, total head, brake horsepower, and efficiency.

PL Determination should include plotting a pump performance curve and reading values from this curve.

33
ACT Determine the number of pumps needed to deliver anticipated flows.

COND Given a system where pumps take water from various locations and elevations, the system-head curves, and anticipated flows.

PL Determination should include pumps in series and pumps in parallel.

34
ACT Determine the capacity of the distribution reservoir.

COND Given average hourly demand rate for a community.

PL Determination should be done using graphical methods and include at least two pumping durations.

Operation and Control of Treatment Plants

PURPOSE

This course is designed to give the learner some experience in using the procedures for the operation and control of water and wastewater treatment plants. The basic variables that affect performance of the different unit operations and analytical procedures used to monitor these variables are also covered.

PREREQUISITES

Before beginning this course the learner should have mastered the instructional objectives for Water/Wastewater Chemistry and Microbiology, Water Pollution Abatement, and Hydrology and Water Supply.

COURSE OUTLINE

The topics covered in this course are listed below. The numbers of the instructional objectives which cover the material in the various topics are also given.

Topic	Objective Number(s)
Operation and Control of Biological Treatment Processes	1-4
Sludge Dewatering and Conditioning	5, 6
Metal Analysis	7, 8
Specific Ion Analysis	9
Chlorination Requirements	10, 11
Turbidity and Coagulation	12, 13
Causes and Control of Taste and Odor	14
Water Softening	15-18
Sand Filters	19-21
Record Keeping and Measurements	22, 23
Plant Safety	24
Operator Certification	25

INSTRUCTIONAL RESOURCES

The following resources are listed to aid the learner in understanding this subject matter, to help the instructor gather lecture materials, and to furnish more in-depth information on a particular topic.

Suggested Textbooks/Reference Materials

IRIS 1037

Other Instructional Resources

Operation and Control of Biological Treatment	IRIS 132, 133, 139, 140, 141, 439, 463, 470, 471, 544, 545, 546, 547, 548, 590, 592, 593, 670, 697, 1020, 1089, 1112, 1260, 1263, 1386, 1760, 1805, 1807, 1817, 2909, 2936 XT-60, XT-61
Sludge Dewatering and Conditioning	IRIS 125, 133, 139, 141, 544, 699, 833, 1260, 1426, 1760, 1790, 1980, 2190
Metal Analysis	IRIS 4, 465, 538, 1028, 1428, 1429, 1431, 1755, 1795, 1915, 1963, 2143, 2144, 2145, 2146, 2265, 2359, 2449, 2910, 2921 VC-29
Specific Ion Analysis	IRIS 465, 467, 480, 488, 865, 1079
Chlorination Requirements	IRIS 38, 139, 141, 465,469, 472, 493, 556, 1078, 1260, 1787, 1800, 1805, 1806, 1999, 2434, 2878
Turbidity and Coagulation	IRIS 139, 465, 469, 493, 546, 547, 829, 836, 1040, 1078, 1260, 1265, 1347, 1446, 1675, 1998
Causes and Control of Taste and Odor	IRIS 139, 469, 494, 576, 1078, 1446, 1683, 1806 VC-68
Water Softening	IRIS 413, 465, 1040, 1075, 1098, 1790, 1806
Sand Filters	IRIS 6, 829, 2207, 2426
Record Keeping and Measurements	IRIS 38, 124, 133, 139, 141, 142, 143, 571, 677, 900, 1089, 1132, 1383, 1386, 1760, 1782, 1944, 2558, 2559
Plant Safety	IRIS 38, 121, 133, 138, 139, 140, 141, 551, 552, 553, 554, 571, 572, 655, 692, 990, 1318, 1470, 1506, 1807, 2419, 2867
Operator Certification	IRIS 20, 21, 22, 1020-1027, 1803

Instructional Objectives

Upon completion of this course, the learner will be able to:

1
ACT Describe problems associated with operation of activated sludge (10), trickling filters (5), and rotating biological contactors (5).

COND Given process schemes.

PL Description should include the visual appearance associated with the problem, as well as the indicated number of problems associated with the operation of the various unit processes.

2
ACT Demonstrate the process control tests used for operation of activated sludge, trickling filters, and rotating biological contactors.

COND Given laboratory equipment, test samples, and laboratory procedure sheets.

PL Demonstration should include accurate performance of oxygen uptake, stability, sludge settleability, and centrifuge tests.

3
ACT Specify methods of correcting the problems associated with operation of activated sludge, trickling filters, and rotating biological contactors.

COND Given slides and descriptions of the problems.

PL Specifications should include the potential methods of correcting a problem with 80% accuracy.

4
ACT Operate pilot size activated sludge, trickling filter, and rotating biological contactors.

COND Given pilot equipment and operating manuals.

PL Student should outline the operating procedure, start up the unit, and assist in operation such that the wastewater is treated to a reasonable plant efficiency during the student's period of responsibility. Eighty percent of the abnormal conditions must be recognized and corrective action taken.

5
ACT Explain the purpose of sludge conditioning before filtration and centrifugation and describe three methods of sludge conditioning.

COND From memory.

PL Explanation should include how and under what conditions each method works. One method should be chemical conditioning.

6
ACT Measure the efficiency of chemical coagulation using the jar test procedure.

COND Given laboratory equipment and laboratory procedure sheet.

PL Measurement should include determining the optimum dose of each of two chemicals based on the test conditions described in the laboratory procedure sheet. The range of the test conditions should be set by the instructor based on his/her knowledge of the sludge.

7
ACT Measure the concentration of metals in sludge and raw wastewater.

COND Given samples, laboratory equipment including an atomic absorption spectrophotometer, and laboratory procedure sheets.

PL Measurements should be within ± 10% of the actual value for 4 out of 5 metals. The metals should include lead, cadmium, copper, zinc, chromium, and nickel.

8
ACT Determine the suitability of sludge (3) for land disposal.

COND Given results of sludge analysis and permissible state and federal loading levels.

PL Determination should include the amount of sludge that may be placed on the land.

9
ACT Demonstrate the use of specific ion analysis.

COND Given a specific ion electrode meter, an operating manual, and laboratory procedure sheets.

PL Demonstration should include analysis on wastewater for ammonia and on water for nitrate. Value determined must be within ± 10% of the actual value.

10
ACT Analyze chlorine residual in water and wastewater using both starch-iodide and amperometric titration methods.

COND Given appropriate samples, laboratory equipment, operating manuals, reagents, and laboratory procedure sheet.

PL Analysis should be performed on two samples for free and/or combined chlorine. Results should fall within ± 10% of the actual values.

11
ACT Determine chlorine residual, demand, and requirement for water and wastewater sample.

COND Given samples, analytical equipment, operating manuals, and laboratory procedure sheets.

PL Determination should fall within ± 10% of the actual value for samples of water and wastewater effluent. Requirement level is to be based on fecal coliform residuals required by NPDES and 1977 Interim Primary Drinking Water Standards.

12
ACT Discuss the variables that affect coagulation of water and wastewater for turbidity and/or color removal.

COND From memory.

PL Discussion should include six of the following: effects of coagulant type, pH, presence of salts, nature of turbidity, temperature, mixing, nuclei and coagulant aids.

13
ACT Determine optimum coagulant dosage using jar test techniques.

COND Given laboratory jar test apparatus, reagents, color and turbidity measurement apparatus, appropriate samples, and laboratory procedure sheet.

PL Determination should be within ± 10% of the optimum pH and polyelectrolyte dose for a particular water sample, given either 1) coagulant dose and pH range over which to test, or 2) coagulant dose, pH, and polyelectrolyte range over which to test.

14
ACT Explain the mechanism and application for activated carbon usage in removal of organic compounds from water.

COND From memory.

PL Explanation should include the effect of surface tension, hydrophilic vs. hydrophobic properties, and adsorption equilibrium and kinetics.

15
ACT Discuss the need for softening of water.

COND From memory.

PL Discussion should include economic aspects of hard water usage, as well as factors to consider in determining the type of softening process to use.

16
ACT Explain the chemistry involved in lime-soda softening of water.

COND Given tables of hardness values and schematics of softening systems.

PL Explanation should include the balanced chemical reactions for softening and explain their relationship to the schematic.

17
ACT Explain the chemistry involved in ion-exchange softening of water.

COND Given schematic of ion-exchange softener.

PL Explanation should include the selectivity series for both anions and cations.

18
ACT Evaluate chemical dosages necessary for lime-soda softening of water.

COND Given jar test apparatus, necessary analytical equipment, and laboratory.

PL Evaluation should include calculation of the theoretical dosages of chemicals based on calcium, magnesium, alkalinity, and sulfate analysis. An actual test of these dosages should be run. Procedure should be 90% correct.

19
ACT Describe the action of particle removal in a sand filter.

COND Given a schematic of sand filter.

PL Description should include the action and the location of straining, flocculation and sedimentation.

20
ACT Describe the operational problems, including causes and corrections, for a sand filter operation.

COND Given schematic of sand filter.

PL Description should include problems such as turbidity, leakage, excessive head buildup and short run length, causes such as poor floc, mud balls, bed cracks, and shrinkage, and corrections such as improved coagulation and washing.

21
ACT Operate a sand filter.

COND Given pilot-size sand filter, operating manual, and procedure sheet.

PL Operation should produce a finished water with less than 1 JTU turbidity.

22
ACT Describe the record keeping necessary for operation of treatment plants.

COND Given treatment plant and state and NPDES forms.

PL Description should include the measurement and location of records necessary to operate water and wastewater treatment plants.

23
ACT Evaluate the statistical distribution of analytical results from a given system that must be monitored.

COND Given several sets of analytical data from an actual treatment plant.

PL Evaluation should include calculation of the mean, median, mode, and standard deviation and be within ± 10% of the actual values.

24
ACT Describe the safety hazards associated with treatment plants and recommend a safety program for the plant employees.

COND Given several plant situations.

PL Description should include five important potential hazards for both water and wastewater treatment plants. Recommendations for the safety program should include at least five important considerations to follow in carrying out a safety program.

25
ACT Study the operator certification requirements at the state level for various size and type of treatment plants.

COND Given operator certification manuals from the student's home state and size and type of treatment plant to be considered.

PL Student should recognize the operation certification level and training requirements for six sizes and types of treatment plants within his/her state.